Urban Design Variables Contributing to Better Transit-Oriented Development

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Contents

Chapter 1

Introduction

Option paper presented in partial fulfillment of the requirements for the degree of Master of City and Regional Planning,

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Michael Dobbins, Richard Dagenhart, Georgia Institute of Technology
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1.1 Abstract

This paper discusses the effects of several urban design criteria on ridership and the possible success of transit oriented development by comparing these measures across transit systems in three different cities, the Paris RER line C, the Washington DC Blue MetroRail line, and Atlanta's MARTA. Number of intersections, block size, linear distance of right-of-way were calculated for a $\frac{1}{4}$ mile network area around each station using GIS. Walking distance between each station was also calculated to see if having multiple stations nearby had any effect on ridership.

1.2 Purpose of Work

Many studies currently exist that attempt to establish criteria for and rate existing stations for suitability for transit-oriented development. In Atlanta, the Atlanta Regional Commission (ARC) and MARTA have developed guidelines for promoting transit-oriented development and created station profiles describing their potentials (MARTA TOD Guidelines 2010). The ARC notes that many of these transit stations are also located within previous Livable Community Initiative (LCI) study areas. This paper attempts to extend these studies and previous work by colleagues of the College of Architecture by comparing network connectivity characteristics adjacent to transit stations in several cities, one US example and one international. We seek to find ranges of the design parameters of block size and count, number of intersections, and length of right-of-way. Comparing these new criteria to the urban fabric surrounding MARTA stations leads to possible policy recommendations facilitating transit-oriented development with more positive and successful results. This fits within Chapter 2 of MARTA's TOD guidelines that discusses density. Though the primary focus of that chapter is density of use, such density is facilitated by the lots, blocks, and streets components of urban form; while the MARTA guidelines currently focus on aspects of the urban environment controlled by zoning ordinances (use, parking, density), this survey asserts that better utilizing controls of subdivision and urban form, can contribute as much to the success of a transit-oriented development.

1.3 Literature Review

Many surveys of urban design characteristics surrounding transit oriented development currently exist. Schlossberg and Brown (2004) in discuss some of the reasoning behind analyzing street network characteristics of transit-oriented development. They assert that the "success of TODs significantly rests on the capacity of pedestrians to navigate and access the range of land uses in close proximity" (p2). They cite such physical measures as block size and intersection density as key measures. Further supporting this claim, they cite Lynch's *Image of the City* and say that "visualizing urban form is an important component to understand walkability" (p4). Their analysis computed these measures within $\frac{1}{4}$ mile and $\frac{1}{2}$ radial (geometric) buffers from transit stops. Krizek (2003) discusses several issues regarding scale of analysis (p276) and the creation of a "neighborhood accessibility" index (p271). For Krizek, scale of anlysis spoke of a dialectic between the 'neighborhood' scale (defined by Perry) and the usual traffic engineering subdivision (transportation analysis zone [TAZ]) network. Key issues of accessibility for Krizek included density, land-use mix, and urban design. Within the urban design category, Krizek cites interconnected streets, small block size, separated bike and pedestrian paths, narrower streets, presence of on-street parking, sidewalks, green spaces, variation in housing design and size, shallow setbacks, and front porches.

Cervero and Kockelman (1997) describes a study that focused on a number of density, diversity, and design characteristics that are thought to influence vehicle miles traveled (VMT). The primary design variables considered in that study were proportion of four-way intersections, proportion of blocks with sidewalks, planting strips, overhead lights, flat terrain, square shape, block face length, sidewalk width, distance between overhead lights, and proportion of commercial parcels with paid parking and side or front-lot on-street parking (p209). In their statistical modeling, average block size was found to be statistically insignificant compared with other design characteristics such as block shape (quadrilateral patterning of blocks) (p212). For non-work trips, in addition to other factors, 'co-existance' of quadrilateralness and number of four-way intersections were found to be associated with decreased VMT (p213).

Finally, Ewing and Cervero (2010) performed a meta-analysis of a large number of transportation and land-use studies. "Built-environment" design variables considered in their survey of more than 50 studies conducted between 1996 and 2009 included intersection/street density (6 studies for VMT, 7 studies for walking, 4 studies for transit use) and percentage of 4-way intersections (3 studies for VMT, 5 studies for walking, and 5 studies for transit use) for VMT, transit use, and walking (p273-274). Though the weighted average elasticities for VMT implied a weak association (-0.12 for both measures), walking and transit were both found to be associated with relatively higher average elasticities: 0.39 (highest weighted elasticity for walking) and -0.06 respectively for walking, 0.23 and 0.29 (highest weighted elasticity) for transit use. The results for walking were explained that " 'walkability' might be limited even if connectivity is excellent when blocks are long," (p275) implying that including block size or perimeter in the analysis might explain more variation in walking rates. Finally, for transit mode share, Cervero and Ewing explain that "high intersection density and great street connectivity shorten access distances and provide more routing options for transit users and transit service providers" (p276). These imply that even though areas with smaller blocks and more intersections might not significantly decrease VMT, they are associated with increased walking and transit use. One additional variable included in the survey was distance to nearest transit stop (6 studies considering VMT, 3 studies each considering walking and transit use). This variable had average elasticities of -0.05, 0.15, and 0.29 respectively and implies that proximity to transit explained most of the variation for transit use in studies within the analysis.

Chapter 2

Study Methodology

City	Washington, DC	Atlanta	Paris RER (C)	Paris Metro
Date of Opening	1976	1979	1977	1900
Network Length (km)	171.2	79.2	185.6	218
(Avg.) Line Length (km)	34.24	39.6	185.6	13.63
Avg. Station Distance (m)	2,014	2,141	2,184	596

This study compares transit systems from three different cities in order to control for variations within each city. One line each from the Washington, DC Metro rail (operated by the Washington Metropolitan Area Transit Authority [WMATA]) and the Paris Reseau Express Regional (RER operated by the Societe Nationale des Chemins de fers Francais [SCNF] / Regie autonome des transport parisiens [RATP]) have been chosen to be compared with all of Atlanta's Metropolitan Atlanta Rapid Transit Authority (MARTA) transit stations.

DC's heavy-rail transit was built at roughly the same time as Atlanta's system and the average distance reported between each station is roughly similar (around 2000 meters), implying similar operating parameters. Phase 1 of the Silver Line in DC through Tysons Corner (Fairfax County) and part of the way to Reston and the Dulles International Airport is scheduled to be put in revenue operation soon, continuing a long series of enhancements to the original network. The WMATA Blue Line service selected for this analysis runs roughly east-west from Springfield, VA, through downtown DC to Maryland's Largo Town Center, and includes several suburban park-and-ride type stations, as well as underground, urban-core stations. Part of the route is also served by Orange Line service. All stations from this line are included in the analysis, except for the stations serving Reagan National Airport and the Pentagon, which do not offer direct access to the street network.

The Paris RER network was built starting in the 1960s and 70s to supplement the existing and successful Metro network and extend it into suburban (extramuros) Paris and is operated partly by the French national railway (SNCF) and the Parisian transit agency (RATP). The RER network continues to develop, including the newest RER E line that operates from Gare Saint Lazare in Paris to Tournan (a nearby suburb). While most comparisons focus on the Paris metro, its frequent service and average distance between stations, and almost exclusive run through intramuros Paris make it a poor comparison to the American systems. The stations on the Paris RER line "C" inside the Peripherique have been chosen for analysis. Line "C" has several branches that connect Paris to numerous suburbs north and south of the city, including Versailles, Pontoise, Massy-Palaiseau, and offers connections to many metro lines and some of the other RER lines. Though the stations considered do not extend outside the city, they nonetheless include different types of station typologies (underground and above-ground), as well as being adjacent to several different urban densities.

For reference, maps obtained from their respective transit agencies have been included starting on the next page.

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

RAIL MAP

Legend

- **Red Line** — Service from North Springs to Airport until 7pm
- **Red Line** — After 7pm from **Lindbergh Center** to **North Springs** only.
- **Gold Line**
- **Blue Line**
- **Interstate Highways**
- **Green Line** — Service to **Edgewood/Candler Park**: weekdays 5am-9am & 3pm-7pm; Service to King Memorial: weekdays 9am-3pm, Sat.- Sun. until 7pm
- **Green Line** — After 7pm, service to **Vine City** only.
- **Stations with free daily parking**
- **Stations with long-term and free daily parking**
- **Stations with restrooms**
- **Q:Express & Limited(Bus Rapid Transit)**

MARTA RideStore
- Airport Station
- Five Points Station — Located at Peachtree St. entrance.

Reduced Fare Office
- Lindbergh Center Station — Located in MARTA Headquarters Building.
- Five Points Station — Located at Forsyth St. entrance

Lost & Found
- Five Points Station — Inside Reduced Fare Office

Regional Connections

Cobb Community Transit
www.cobbcct.org
(770) 427-4444
Stations served:
- Dunwoody
- Arts Center
- Midtown
- North Avenue
- Peachtree Center
- Civic Center
- Hamilton E. Holmes
- Five Points

Gwinnett County Transit
www.gctransit.com
(770) 822-5010
Stations served:
- Doraville
- Arts Center
- Midtown
- North Avenue
- Civic Center
- Peachtree Center
- Lindbergh Center
- Five Points

GRTA Xpress
www.xpressga.com
(404) 463-4782
Stations served:
- Civic Center
- Arts Center
- North Avenue
- Peachtree Center
- Medical Center
- North Springs
- Dunwoody
- Midtown
- Five Points

Zipcar (a car sharing service)
www.zipcar.com 1-866-4ZIPCAR

Amtrak
www.amtrak.com 1-800-USA-RAIL
Bus Route 110 from Arts Center Station

Greyhound Bus Lines/Southeastern Stages
www.greyhound.com 1-800-231-2222
Exit at Garnett Station

Hartsfield-Jackson Atlanta International Airport
www.atlanta-airport.com (800) 897-1910

www.itsmarta.com 404-848-5000 TTY: 404-848-5665 Accessible Format: 404-848-5202

System Map

wmata.com
Customer Information Service: 202-637-7000
TTY Phone: 202-638-3780

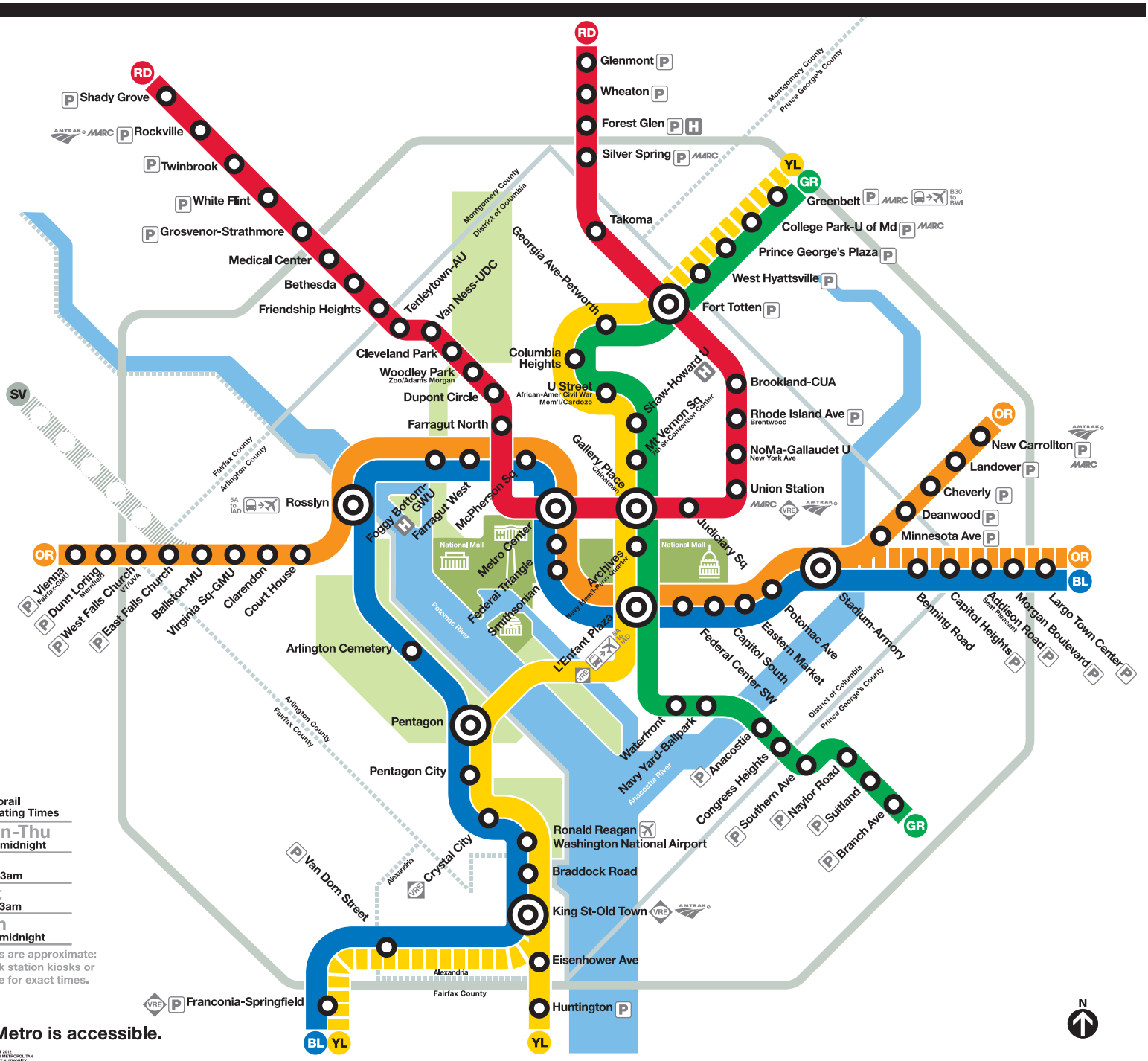
Legend

- RD Red Line • Glenmont to Shady Grove
- OR Orange Line • New Carrollton to Vienna
- BL Blue Line • Franconia-Springfield to Largo Town Center
- GR Green Line • Branch Ave to Greenbelt
- YL Yellow Line • Huntington to Fort Totten
- SV Silver Line • Future Dulles Corridor Line

Station Features
- Bus to Airport
- Parking
- Hospital
- Airport

Connecting Rail Systems
Amtrak, VRE, MARC

Transfer Station
Planned Station
Under Construction
Full-Time Service
Station in Service
Rush-Only Service: Monday-Friday 6:30am - 9:00am 3:30pm - 6:00pm



Metrorail Operating Times

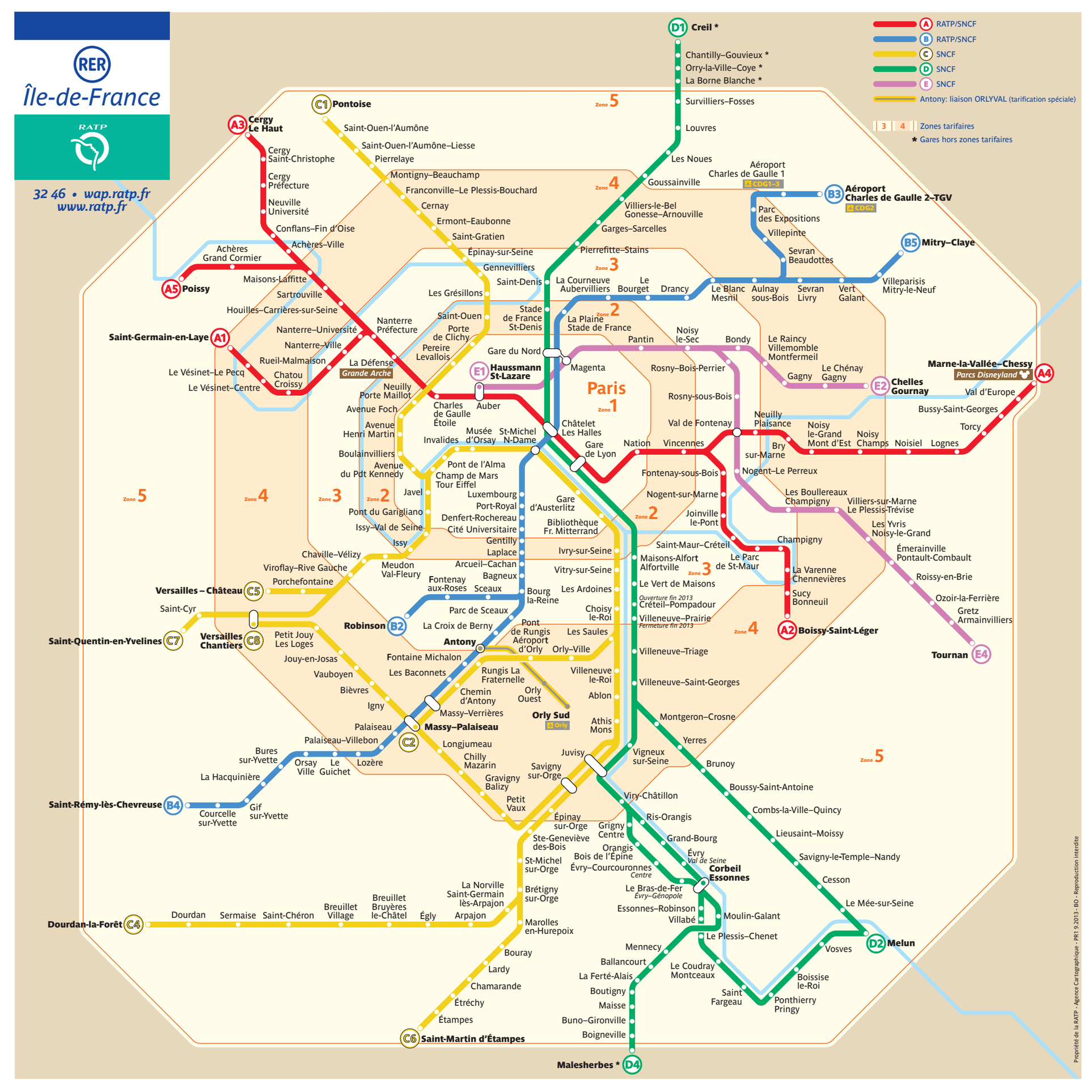
Mon-Thu	5am-midnight
Fri	5am-3am
Sat	7am-3am
Sun	7am-midnight

Times are approximate: check station kiosks or online for exact times.

Metro is accessible.

N

- No Smoking
- No Eating or Drinking
- No Animals (except service animals)
- No Audio (without earphones)
- No Littering or Spitting
- No Dangerous or Flammable Items


RER
Île-de-France
RATP
32 46 • wap.ratp.fr
www.ratp.fr
A RATP/SNCF
B RATP/SNCF
C SNCF
D SNCF
E SNCF
Antony: liaison ORLYVAL (tarification spéciale)
3 4 Zones tarifaires
* Gares hors zones tarifaires
Paris
Zone 1
Zone 2
Zone 3
Zone 4
Zone 5
D1 Creil *
Chantilly–Gouvieux *
Orry-la-Ville–Coye *
La Borne Blanche *
Survilliers–Fosses
Louvres
Les Noues
Goussainville
Aéroport Charles de Gaulle 1
CDG1-3
B3 Aéroport Charles de Gaulle 2-TGV
CDG2
Parc des Expositions
Villepinte
Sevran Beaudottes
B5 Mitry–Claye
Villeparisis Mitry-le-Neuf
Le Blanc Mesnil
Aulnay sous-Bois
Sevran Livry
Vert Galant
Drancy
Le Bourget
La Courneuve Aubervilliers
Pierrefitte–Stains
Villiers-le-Bel Gonesse–Arnouville
Garges–Sarcelles
C1 Pontoise
Saint-Ouen-l'Aumône
Saint-Ouen-l'Aumône–Liesse
Pierrelaye
Montigny–Beauchamp
Franconville–Le Plessis-Bouchard
Cernay
Ermont–Eaubonne
Saint-Gratien
Épinay-sur-Seine
Gennevilliers
Saint-Denis
Les Grésillons
Stade de France St-Denis
La Plaine Stade de France
A3 Cergy Le Haut
Cergy Saint-Christophe
Cergy Préfecture
Neuville Université
Conflans–Fin d'Oise
Achères–Ville
Achères Grand Cormier
A5 Poissy
Maisons-Laffitte
Sartrouville
Houilles–Carrières-sur-Seine
Saint-Germain-en-Laye A1
Nanterre–Université
Nanterre–Ville
Rueil-Malmaison
Chatou Croissy
Le Vésinet–Le Pecq
Le Vésinet–Centre
Nanterre Préfecture
La Défense Grande Arche
Neuilly Porte Maillot
Avenue Foch
Avenue Henri Martin
Boulainvilliers
Avenue du Pdt Kennedy
Saint-Ouen
Porte de Clichy
Pereire Levallois
Gare du Nord
Magenta
Pantin
Noisy le-Sec
Bondy
Le Raincy Villemomble Montfermeil
Gagny
Le Chénay Gagny
E1 Haussmann St-Lazare
Charles de Gaulle Étoile
Auber
Invalides
Musée d'Orsay
St-Michel N-Dame
Châtelet Les Halles
Gare de Lyon
Nation
Vincennes
Rosny–Bois-Perrier
Rosny-sous-Bois
Val de Fontenay
Neuilly Plaisance
Bry sur-Marne
Noisy le-Grand Mont d'Est
Noisy Champs
Noisiel
Lognes
Marne-la-Vallée–Chessy
Parcs Disneyland
A4
E2 Chelles Gournay
Val d'Europe
Bussy-Saint-Georges
Torcy
Pont de l'Alma
Champ de Mars Tour Eiffel
Javel
Pont du Garigliano
Issy–Val de Seine
Issy
Luxembourg
Port-Royal
Denfert-Rochereau
Cité Universitaire
Gentilly
Laplace
Arcueil–Cachan
Bagneux
Sceaux
Gare d'Austerlitz
Bibliothèque Fr. Mitterrand
Ivry-sur-Seine
Vitry-sur-Seine
Les Ardoines
Bourg la-Reine
Fontenay-sous-Bois
Nogent–Le Perreux
Nogent-sur-Marne
Joinville le-Pont
Les Boullereaux Champigny
Villiers-sur-Marne Le Plessis-Trévise
Champigny
Saint-Maur–Créteil
Le Parc de St-Maur
Maisons-Alfort Alfortville
Le Vert de Maisons
Ouverture fin 2013
Créteil–Pompadour
Villeneuve–Prairie
Fermeture fin 2013
Les Yvris Noisy-le-Grand
Émerainville Pontault-Combault
La Varenne Chennevières
Roissy-en-Brie
Ozoir-la-Ferrière
Gretz Armainvilliers
A2 Boissy-Saint-Léger
Tournan E4
Versailles – Château C5
Chaville–Vélizy
Viroflay–Rive Gauche
Porchefontaine
Saint-Cyr
Versailles Chantiers C8
Saint-Quentin-en-Yvelines C7
Petit Jouy Les Loges
Meudon Val-Fleury
Robinson B2
La Croix de Berny
Parc de Sceaux
Fontenay aux-Roses
Choisy le-Roi
Pont de Rungis Aéroport d'Orly
Les Saules
Antony
Orly–Ville
Fontaine Michalon
Les Baconnets
Jouy-en-Josas
Vauboyen
Bièvres
Igny
Massy–Verrières
Massy–Palaiseau
Palaiseau
Palaiseau–Villebon
Rungis La Fraternelle
Chemin d'Antony
Orly Ouest
Orly Sud
Orly
Athis Mons
Villeneuve le-Roi
Ablon
Villeneuve–Triage
Villeneuve–Saint-Georges
Montgeron–Crosne
Yerres
Brunoy
Boussy-Saint-Antoine
Combs-la-Ville–Quincy
Lieusaint–Moissy
Savigny-le-Temple–Nandy
Cesson
Le Mée-sur-Seine
Vosves
D2 Melun
Boissise le-Roi
Ponthierry Pringy
Saint Fargeau
Le Coudray Montceaux
Le Plessis–Chenet
Moulin-Galant
Villabé
Essonnes–Robinson
Le Bras-de-Fer Évry–Génopole
Corbeil Essonnes
Évry Val de Seine
Évry–Courcouronnes Centre
Bois de l'Épine
Orangis
Grigny Centre
Ris-Orangis
Viry-Châtillon
Juvisy
Vigneux sur-Seine
Savigny sur-Orge
Épinay sur-Orge
Ste-Geneviève des-Bois
St-Michel sur-Orge
Brétigny sur-Orge
Marolles en-Hurepoix
Bouray
Lardy
Chamarande
Étréchy
Étampes
C6 Saint-Martin d'Étampes
Malesherbes * D4
Mennecy
Ballancourt
La Ferté-Alais
Boutigny
Maisse
Buno–Gironville
Boigneville
Dourdan-la-Forêt C4
Dourdan
Sermaise
Saint-Chéron
Breuillet Village
Breuillet Bruyères le-Châtel
Égly
Arpajon
La Norville Saint-Germain lès-Arpajon
Saint-Rémy-lès-Chevreuse B4
Courcelle sur-Yvette
Gif sur-Yvette
La Hacquinière
Bures sur-Yvette
Orsay Ville
Le Guichet
Lozère
Longjumeau
Chilly Mazarin
Gravigny Balizy
Petit Vaux
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2.1 Data and Measurements

Station areas will be defined using GIS network analysis around stations along each line. A distance of $\frac{1}{4}$ mile was chosen to model the potential area reachable by a five-minute walk from station exits. These station areas are to be compared across several simple quantitative urban form criteria: block count and size, number of intersections, and linear feet of right-of-way. These four variables are a way to model the general density of the street network from a pedestrian perspective and will attempt to explain published entry/exit/usage data. Finally, walking distances were calculated between each station to attempt to model situations where multiple stations could be chosen by a given user.

The Atlanta Regional Commission and Fulton County provide usable data for the Atlanta-area, including road-centerlines suitable for use in network analysis, building footprints, and parcels. Data for DeKalb County was manually reconstructed from available aerial photography. The road centerline network from the Atlanta Regional Commission was used (2008). Highways and on-ramps were removed prior to performing Network Analysis. The network was checked against currently available aerial photography. Roadway segments were corrected so that appropriate ROW centerlines were counted only once, "non-ROW" footpaths, parking aisles, etc. were removed, and all intersections were correctly modeled. Ridership data were extracted from the MARTA Station TOD profiles published with 2010 daily ridership data.

Recent data from the Mairie of Paris (City of Paris) and RATP are freely available online (opendata.paris.fr and ratp.fr) and include locations of stations, sidewalks, building footprints, and a raster parcel layer. Ridership data were not available for the SNCF-managed line C. The opendata.fr network included many other urban infrastructure elements other than roadway segments (footpaths, stairs, parking aisles, bike paths, tunnels). These were retained in the initial Network Analysis, but removed during data processing to avoid counting them as right-of-way. Roadway segments were further corrected so that appropriate ROW centerlines were counted only once, "non-ROW" footpaths, parking aisles, etc. were removed, and all intersections were correctly modeled.

Finally, data for the Washington DC metropolitan area are available from the Office of the City Administrator website (data.dc.gov) and the Census Bureau's TIGER products. Ridership data from WMATA were downloaded from the PlanItMetro data distribution site and summarize entries data from May 2012 during weekdays. After using network analyst to generate station areas, the Washington DC, Virginia, and Maryland road networks were modified manually to better reflect linear ROW and intersection structure, similar to that which was done for Atlanta and Paris.

Chapter 3

Analysis and Results

3.1 Results

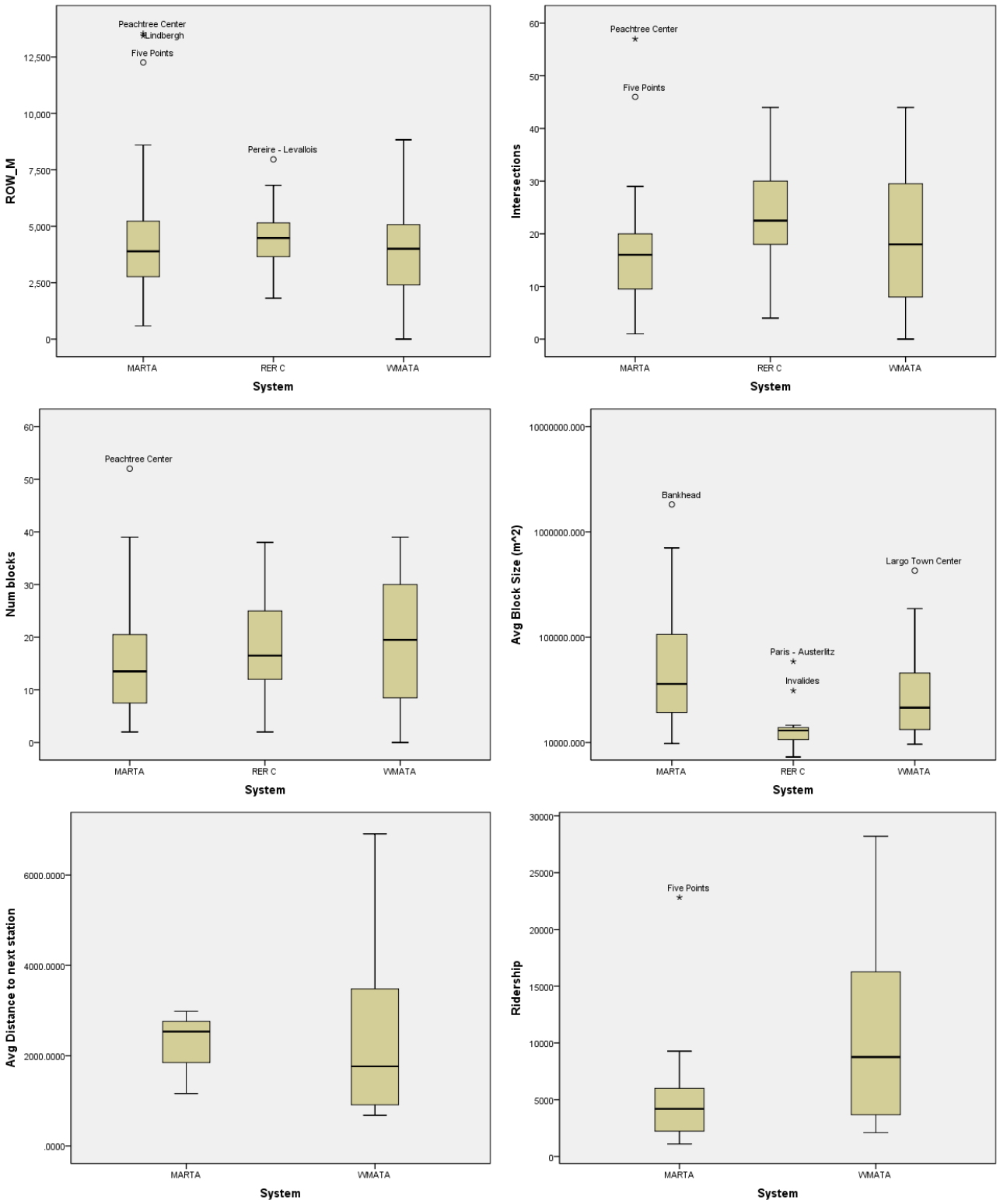
3.1.1 Summary Statistics

Descriptive statistics for each of the variables considered are presented in Table 3.1 below and were produced using the SPSS statistical software. Figures below present box plots comparing variables graphically between cities/systems. Number of cases processed are 36 MARTA stations, 14 RER C stations, and 24 WMATA stations.

Table 3.1: Descriptive Statistics

Right of Way (meters)	**Minimum**	**Mean**	**Median**	**Maximum**	**Std. Deviation**
MARTA	586.42	4,575.44	3,892.39	13,539.51	3,139.22
RER C	1,811.27	4,536.29	4,478.15	7,964.21	1,623.23
WMATA Blue Line	-	3,884.66	4,003.97	8,831.59	2,126.03
Intersections					
MARTA	1	16.44	16	57	11.38
RER C	4	23.79	23	44	10.69
WMATA Blue Line	-	18.79	18	44	12.93
Avg Block Size (m^2)					
MARTA	9,785.14	165,267.76	36,079.89	1,820,123.00	338,960.38
RER C	7,300.00	16,636.21	13,029.50	58,813.00	13,347.70
WMATA Blue Line	-	58,003.81	21,427.38	428,592.97	93,754.42
Number of Blocks					
MARTA	2	15.75	14	52	11.39
RER C	2	18.29	17	38	10.34
WMATA Blue Line	-	19.54	20	39	12.35
Avg Distance to Next Station (m)					
MARTA	1,162.86	2,226.41	2,533.71	2,982.66	948.02
WMATA Blue Line	678.80	2,359.37	1,764.03	6,912.33	1,823.81
Daily Ridership (per station)					
MARTA	1,101.00	4,723.61	4,195.50	22,821.00	3825.52
WMATA Blue Line	2,097.45	10,327.75	8,757.14	28,199.27	7,636.57

Figure 3.1: Boxplots



3.1.2 Regression

Performing a linear regression with WMATA and MARTA datasets with SPSS produced a model with R-square of 0.279 indicating that the urban design variables chose somewhat loosely explain variation in ridership across

stations. With all variables present (intersections, ROW length, block size, number of blocks, and distance to next station), only number of intersections was found to be a statistically significant predictor.

WMATA/MARTA	Coefficient	Significance
ROW (m)	-.890	0.050
Intersections	628.126	0.002
Avg Block Size (m^2)	-0.004	0.258
Num blocks	-334.854	0.058
Avg Distance to next station	-0.513	0.434

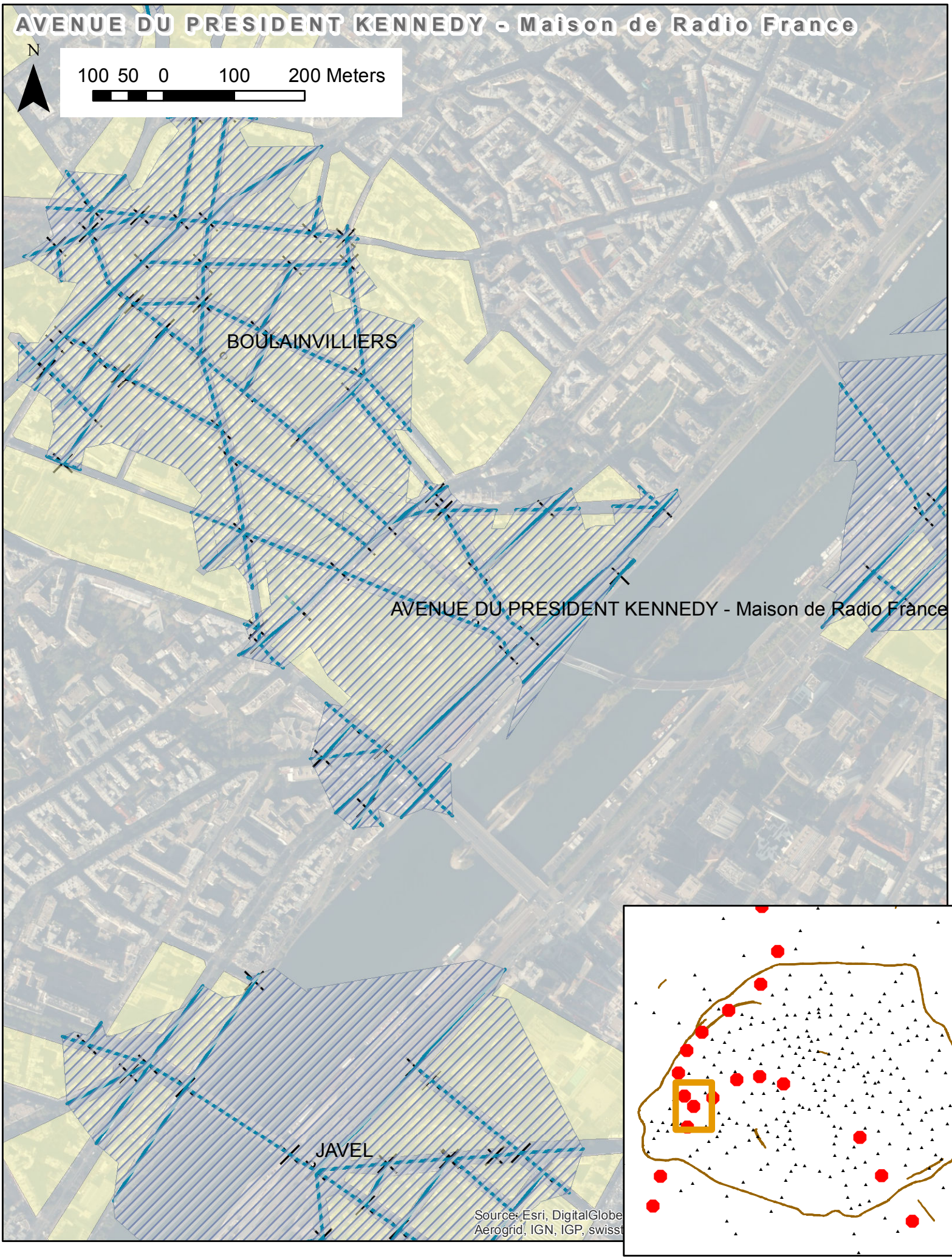
Perofrming the same regression with WMATA only produces the following output with R-square of 0.489 indicating slightly less variability in prediction. Additionally, number of blocks becomes less significant, though ROW length becomes slightly more significant.

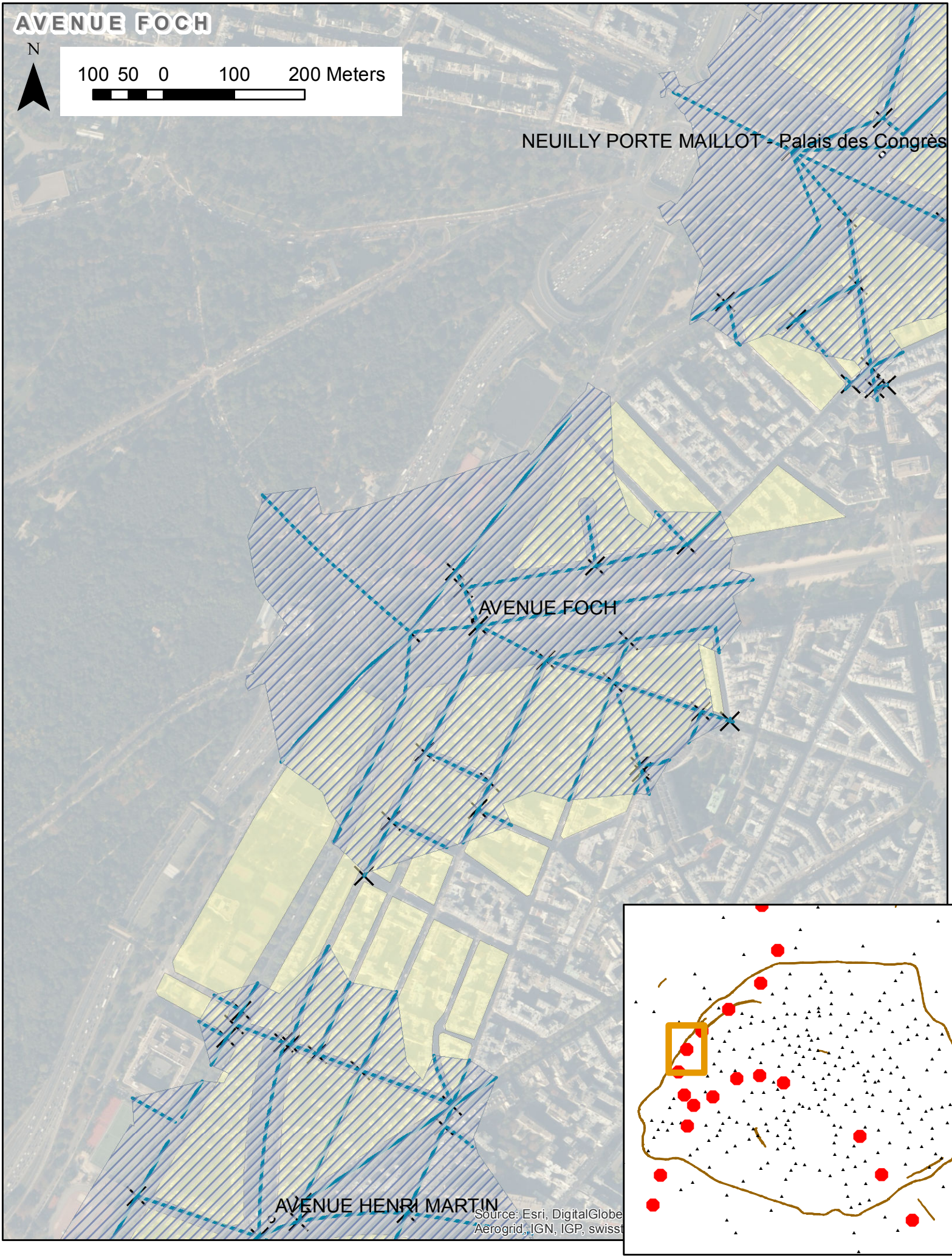
WMATA	Coefficient	Significance
ROW (m)	-2.03	0.08
Intersections	916.92	0.00
Avg Block Size (m^2)	-0.02	0.33
Num blocks	-624.59	0.05
Avg Distance to next station	-1.06	0.29

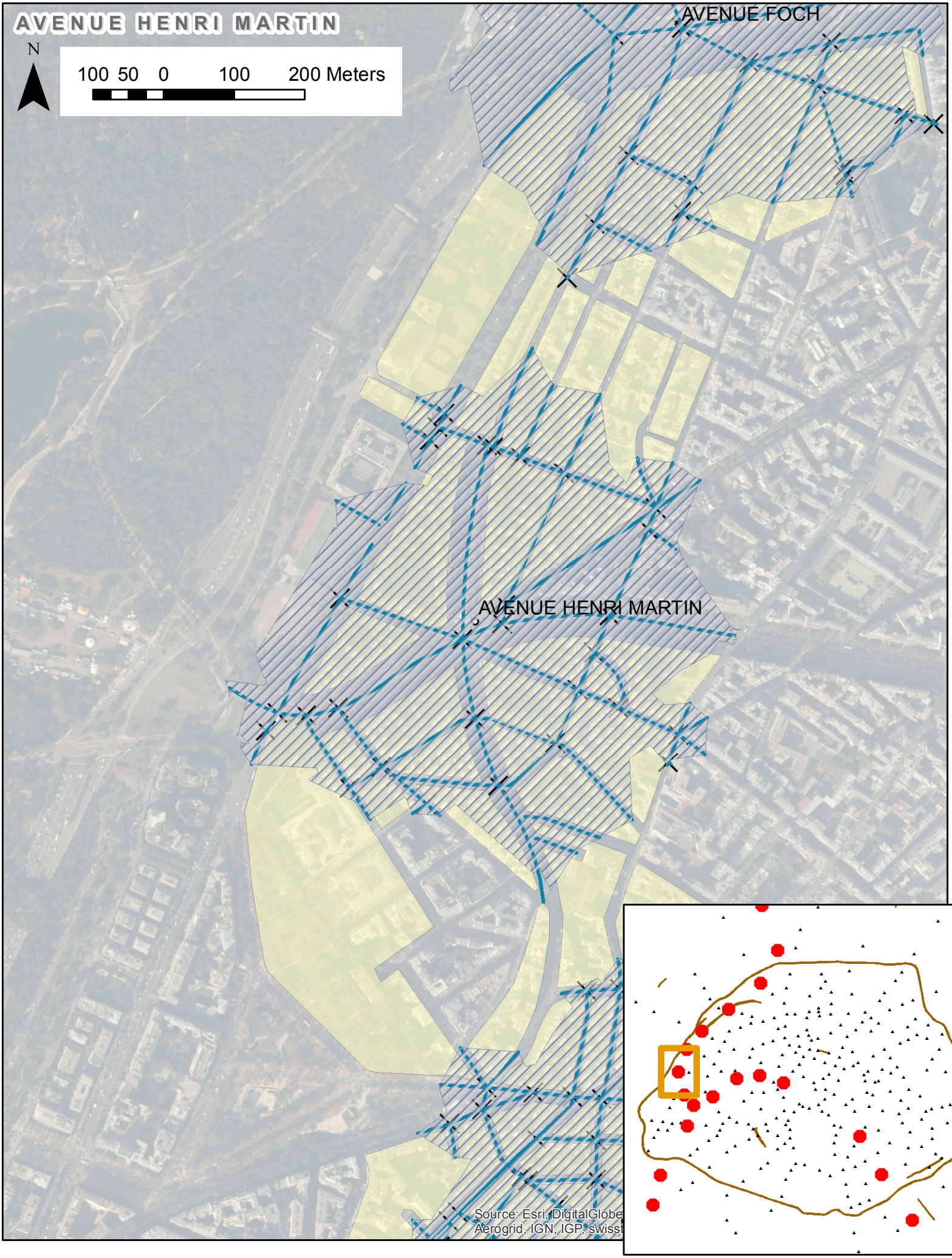
Finally, performing the regression with only MARTA values produces the following output with R-square of 0.307, which while better than all values together, explains less variation than do the data for WMATA. Further, no variables were found to be statistically significant.

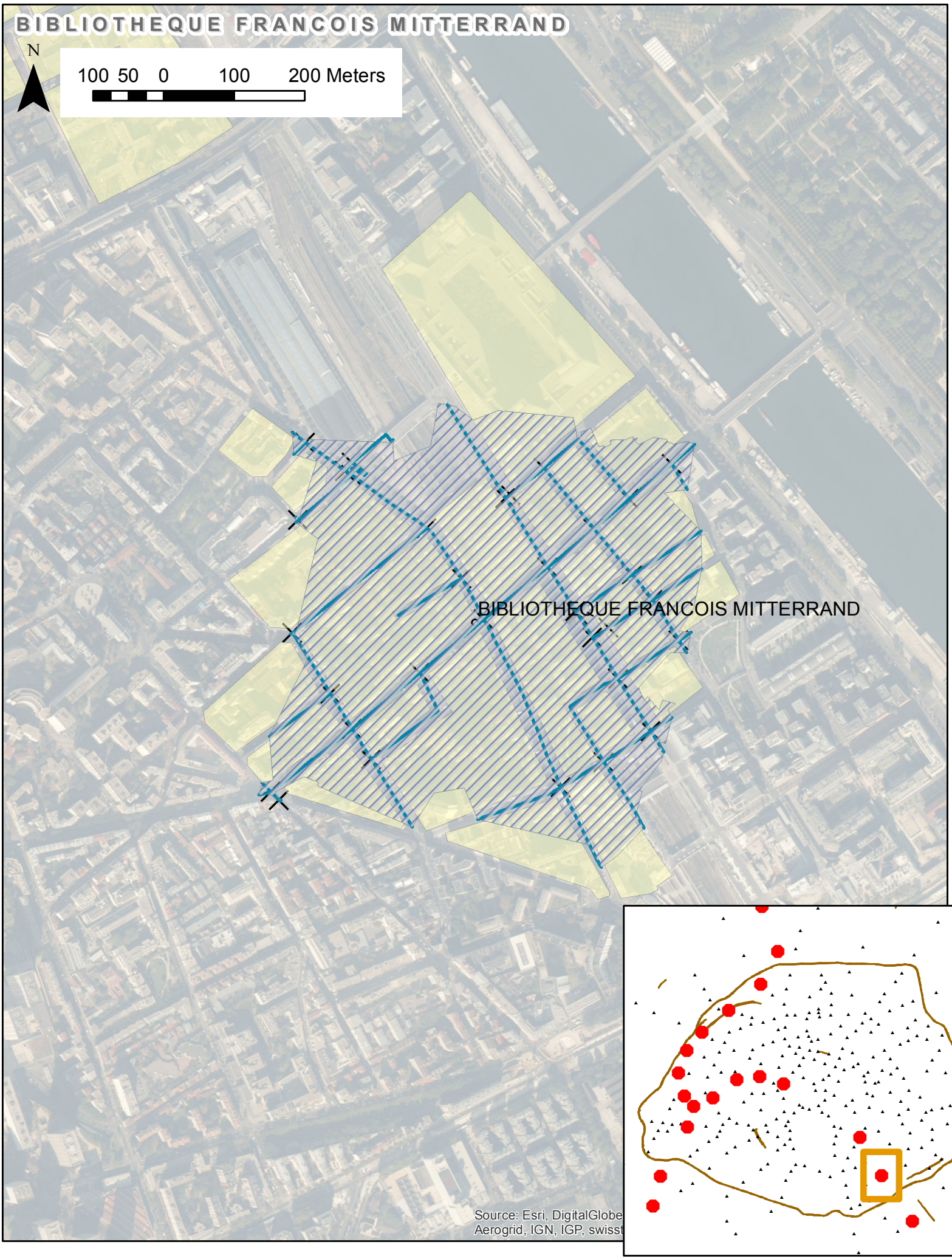
MARTA	Coefficient	Significance
ROW (m)	0.68	0.09
Intersections	-10.06	0.96
Avg Block Size (m^2)	0.00	0.56
Num blocks	9.95	0.95
Avg Distance to next station	-0.25	0.71

3.2 Maps of Transit Station Areas


AVENUE DU PRESIDENT KENNEDY - Maison de Radio France
N
100 50 0 100 200 Meters
BOULAINVILLIERS
AVENUE DU PRESIDENT KENNEDY - Maison de Radio France
JAVEL
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


AVENUE FOCH
N
100 50 0 100 200 Meters
NEUILLY PORTE MAILLOT - Palais des Congrès
AVENUE FOCH
AVENUE HENRI MARTIN
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


AVENUE HENRI MARTIN
N
100 50 0 100 200 Meters
AVENUE FOCH
AVENUE HENRI MARTIN
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


BIBLIOTHEQUE FRANCOIS MITTERRAND
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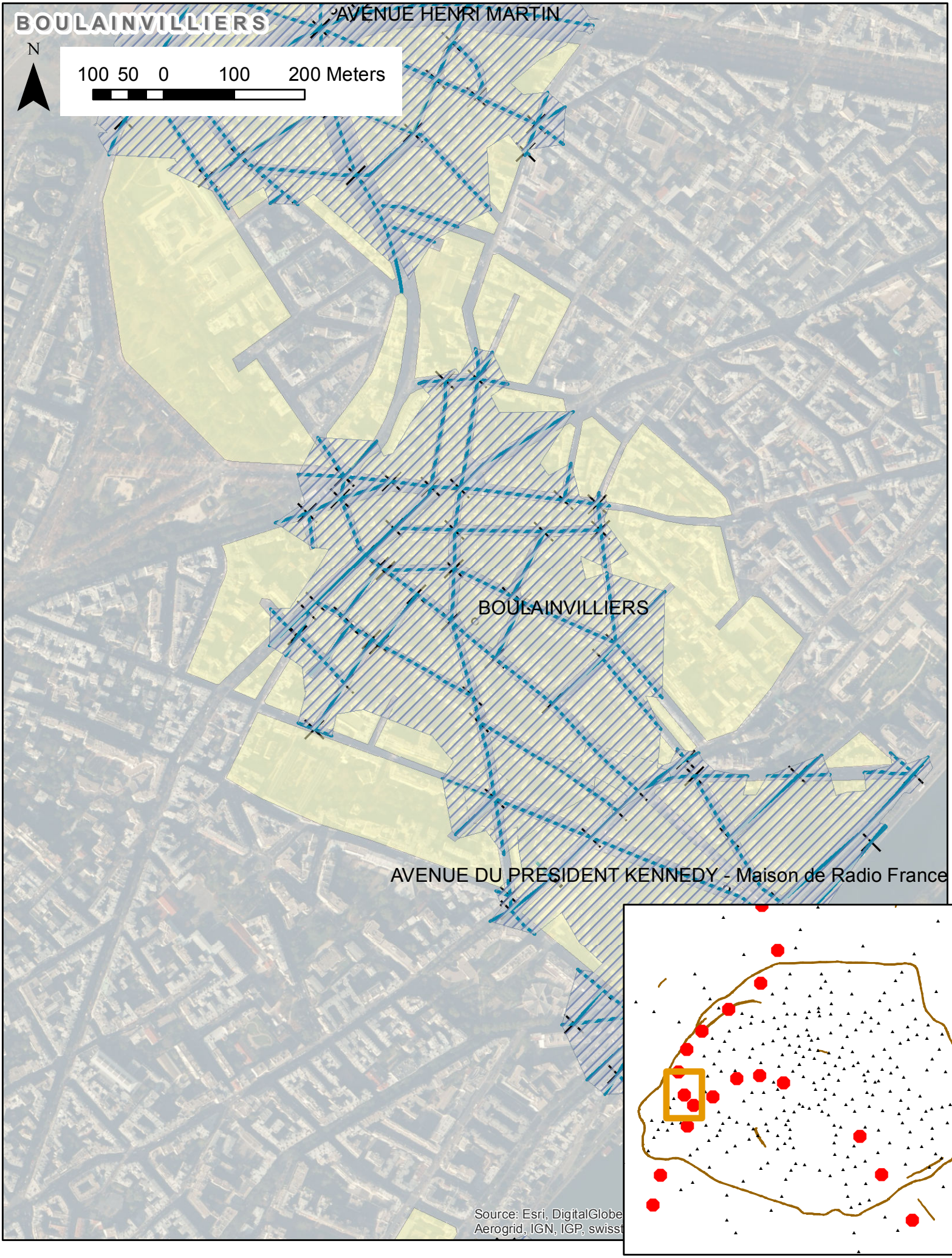
BIBLIOTHEQUE FRANCOIS MITTERRAND
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


BOULAINVILLIERS
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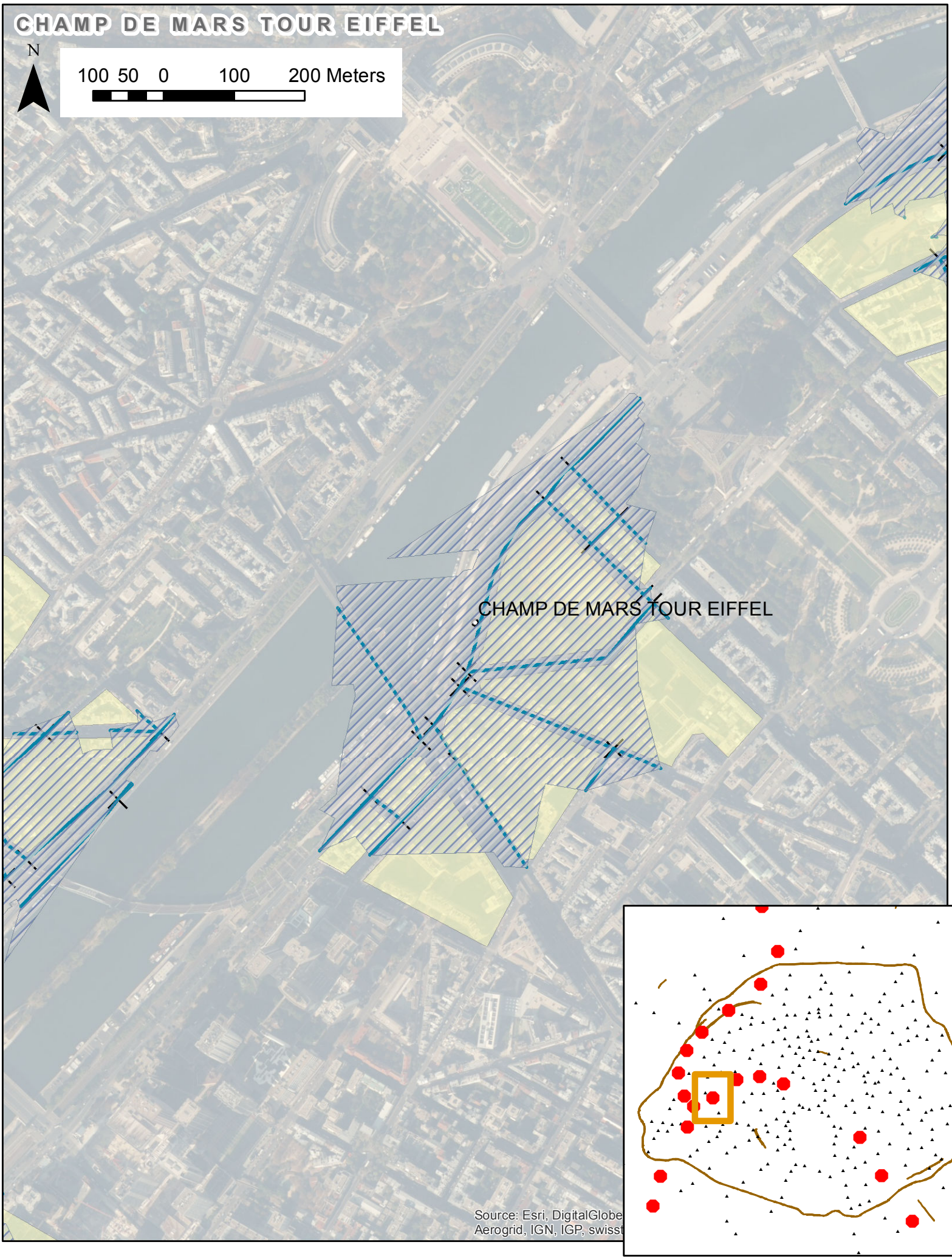
100 50 0 100 200 Meters
AVENUE HENRI MARTIN
BOULAINVILLIERS
AVENUE DU PRESIDENT KENNEDY - Maison de Radio France
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


CHAMP DE MARS TOUR EIFFEL
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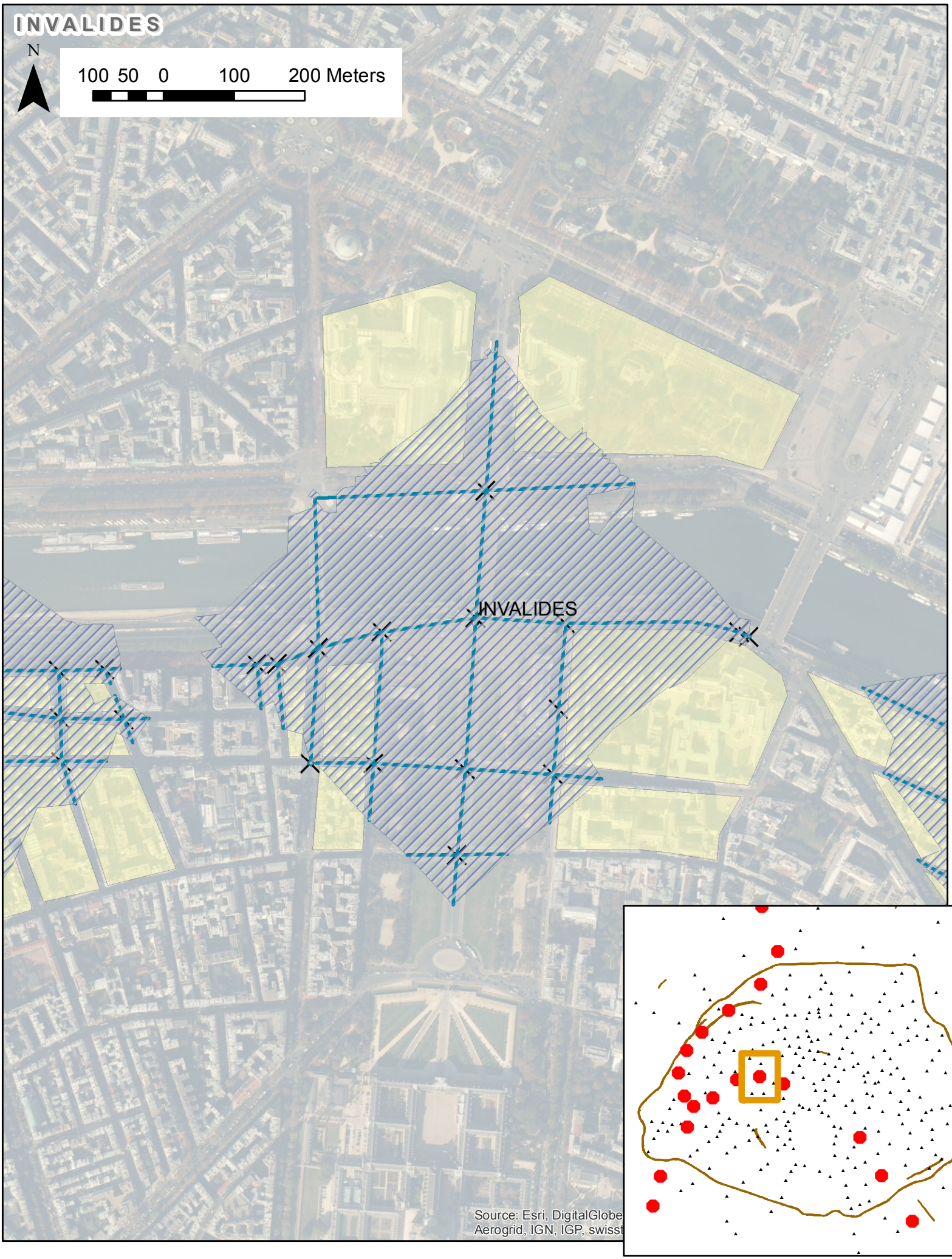
CHAMP DE MARS TOUR EIFFEL
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


INVALIDES
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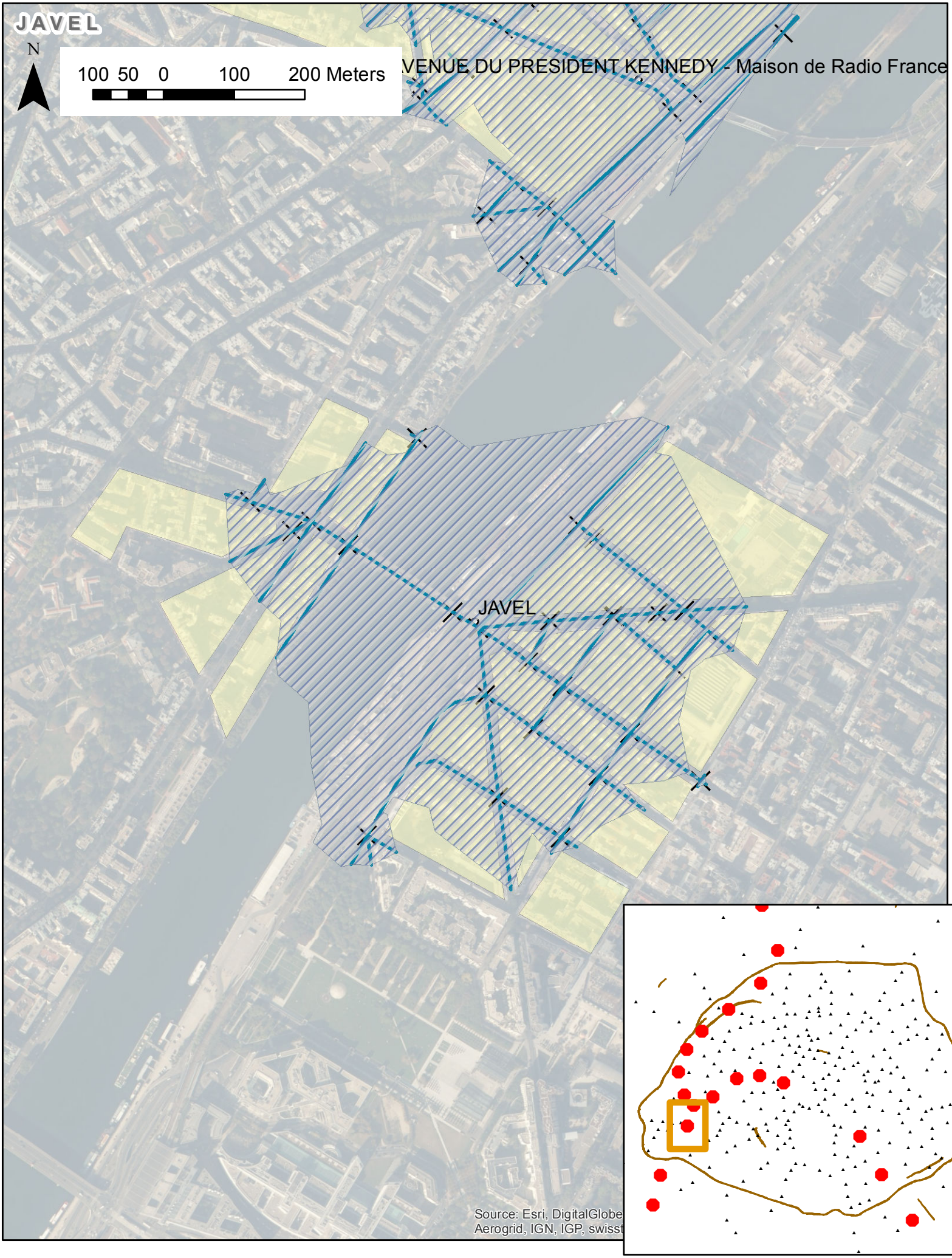
INVALIDES
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


JAVEL
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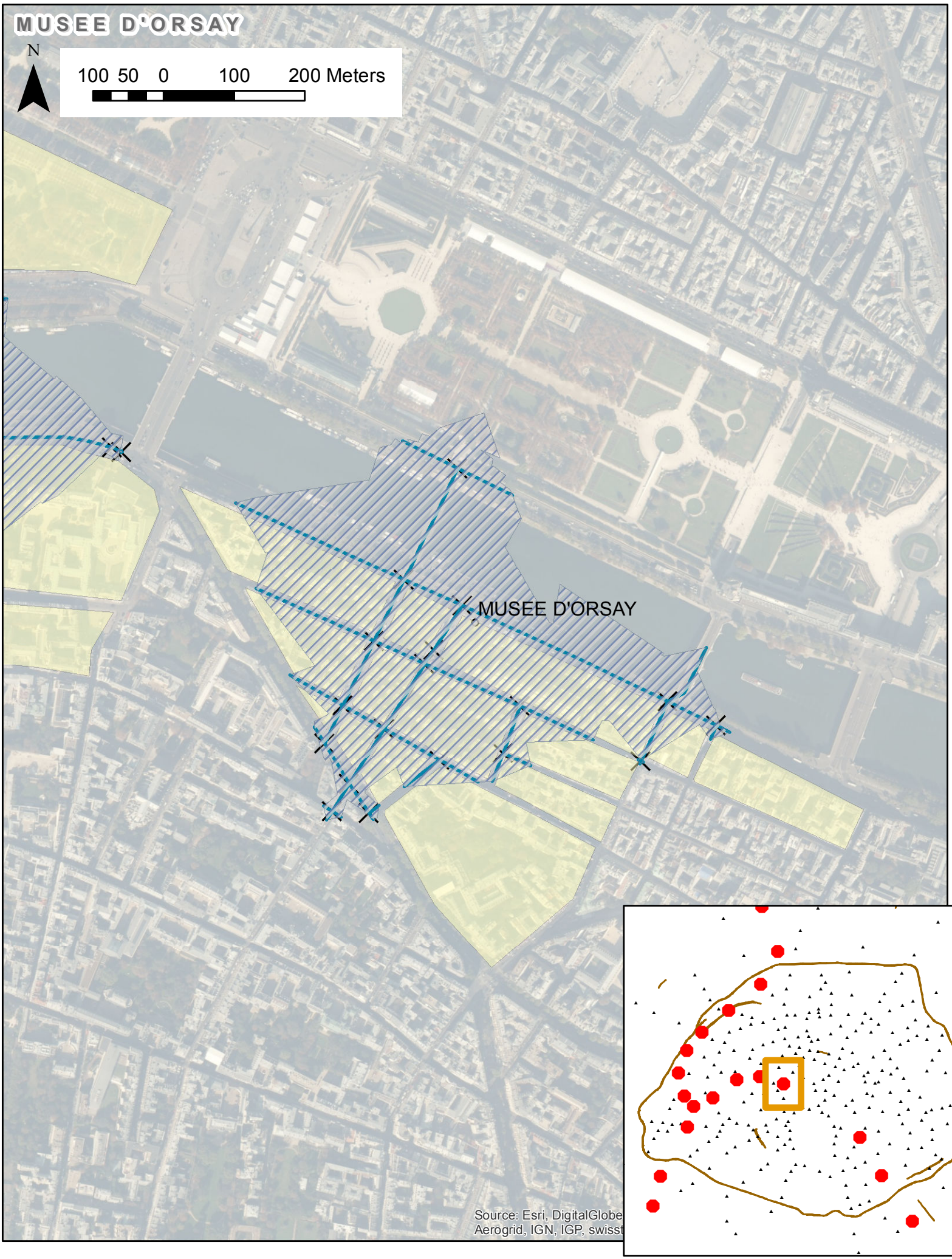
100 50 0 100 200 Meters
VENUE DU PRESIDENT KENNEDY - Maison de Radio France
JAVEL
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


MUSEE D'ORSAY
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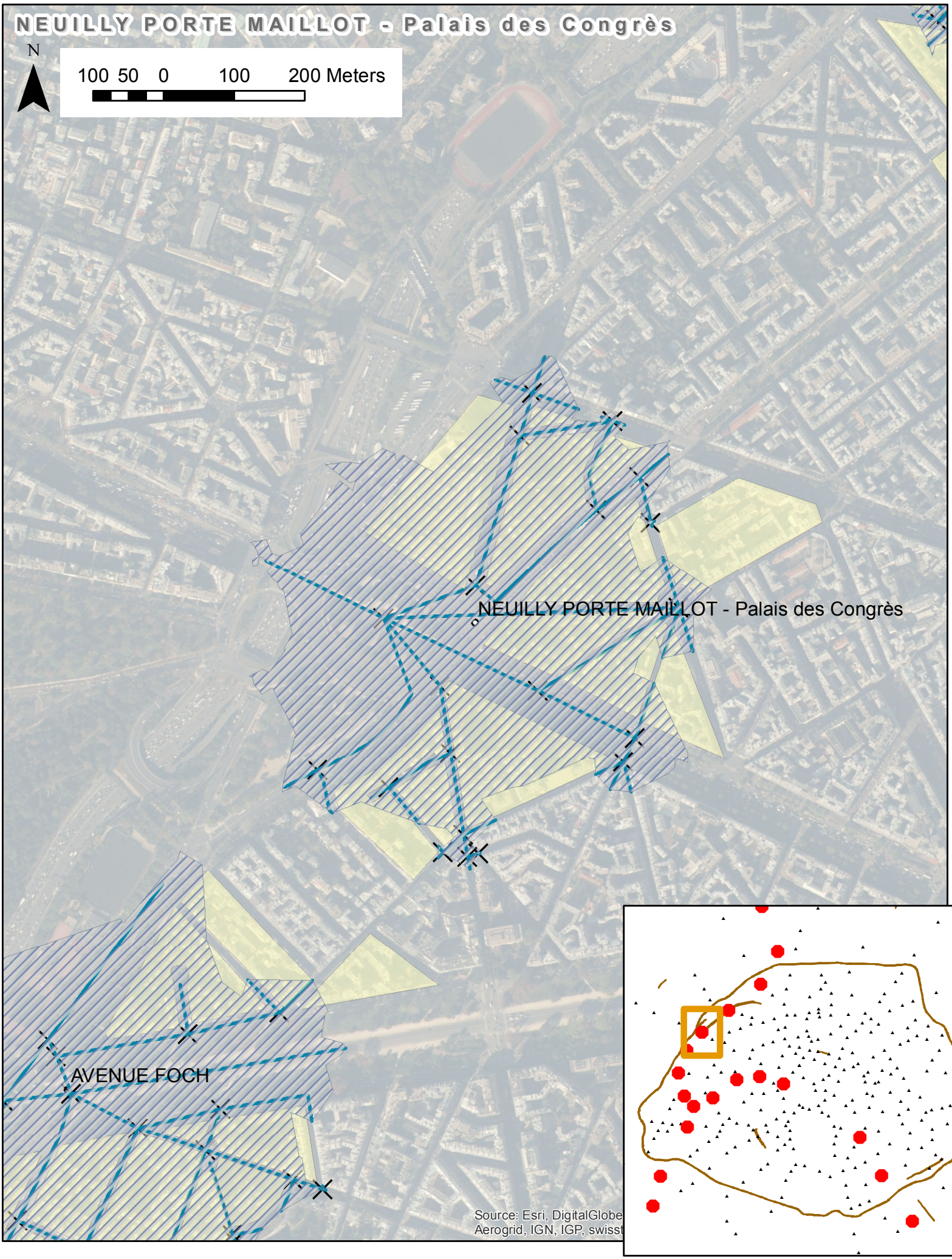
MUSEE D'ORSAY
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


NEUILLY PORTE MAILLOT - Palais des Congrès
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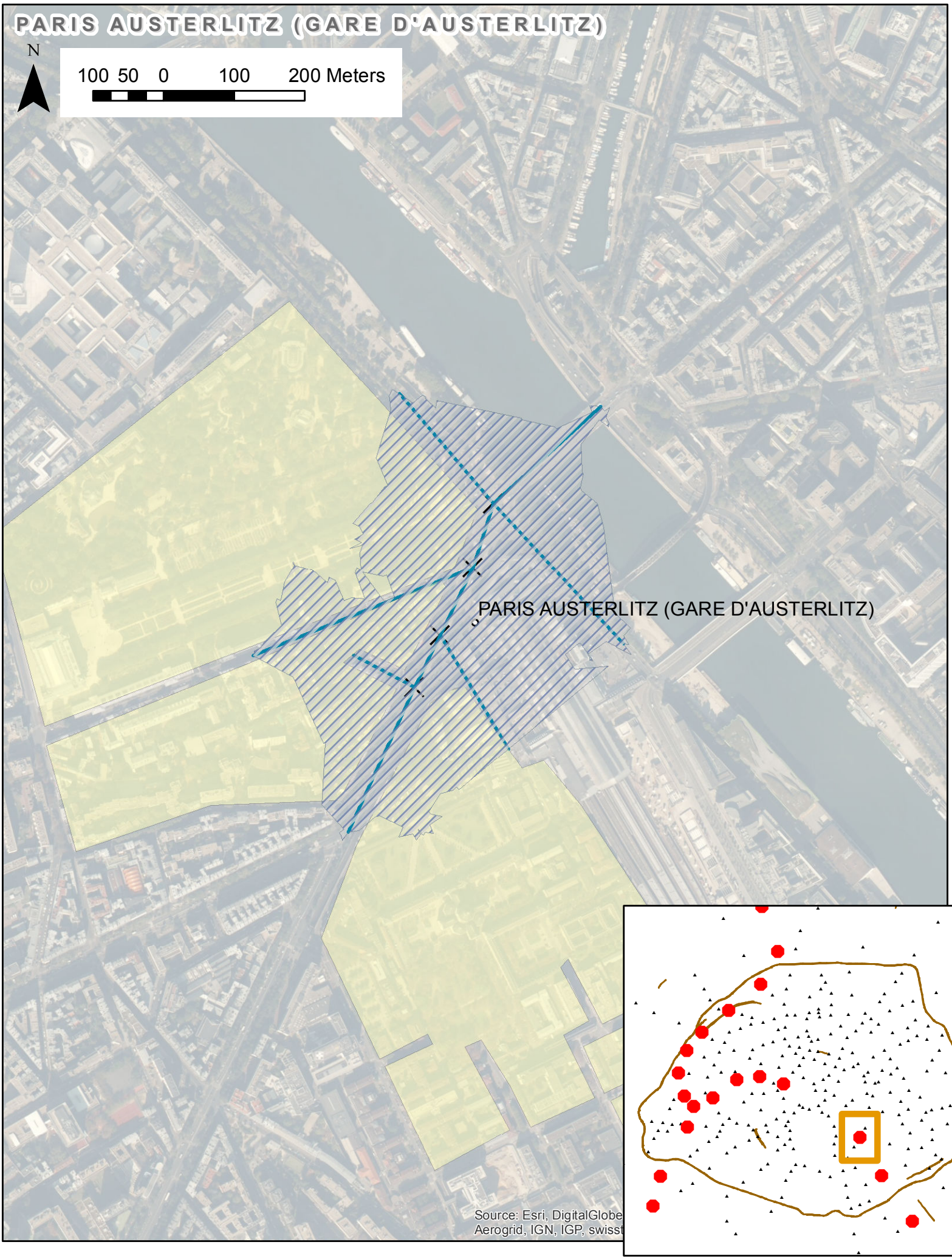
NEUILLY PORTE MAILLOT - Palais des Congrès
AVENUE FOCH
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


PARIS AUSTERLITZ (GARE D'AUSTERLITZ)
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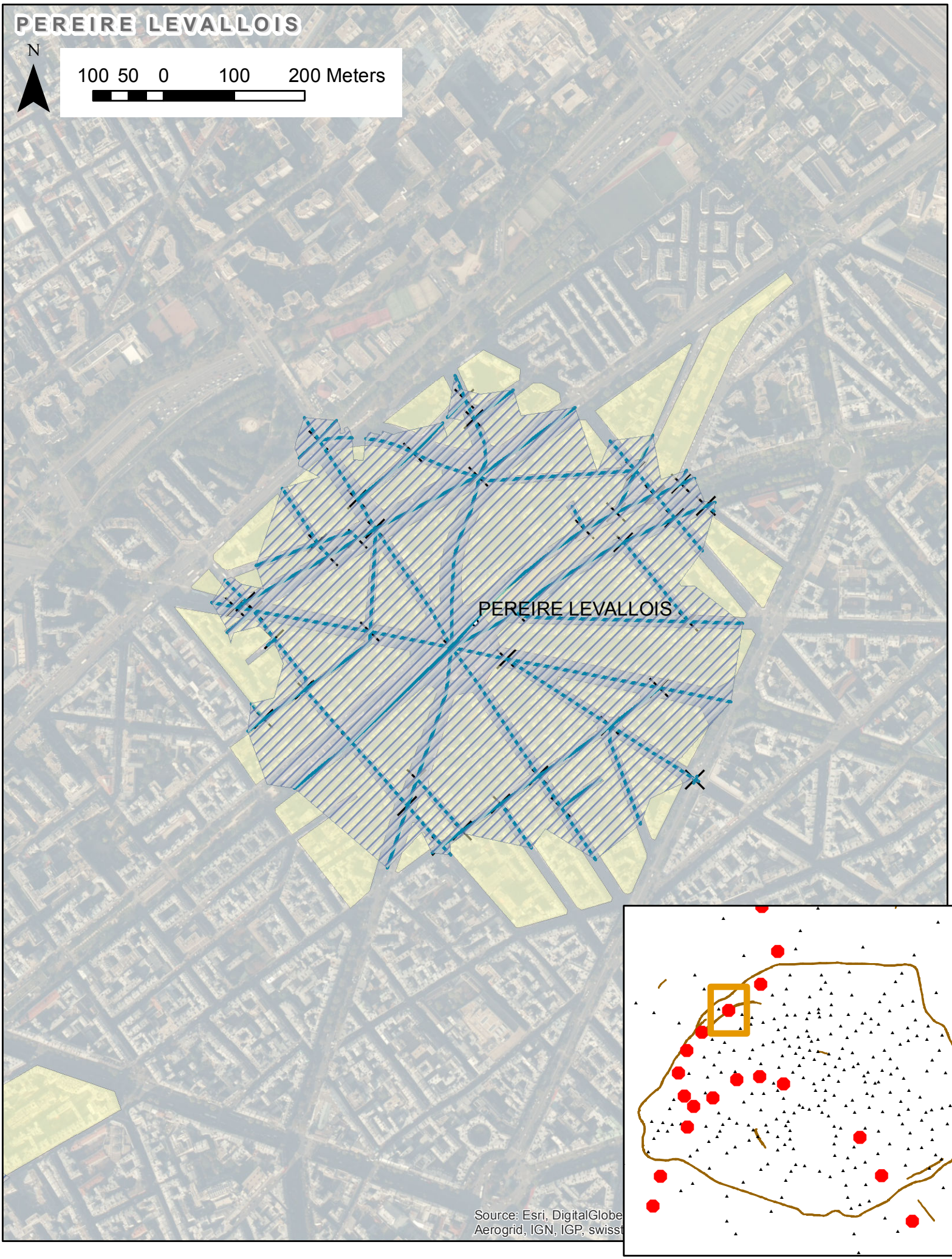
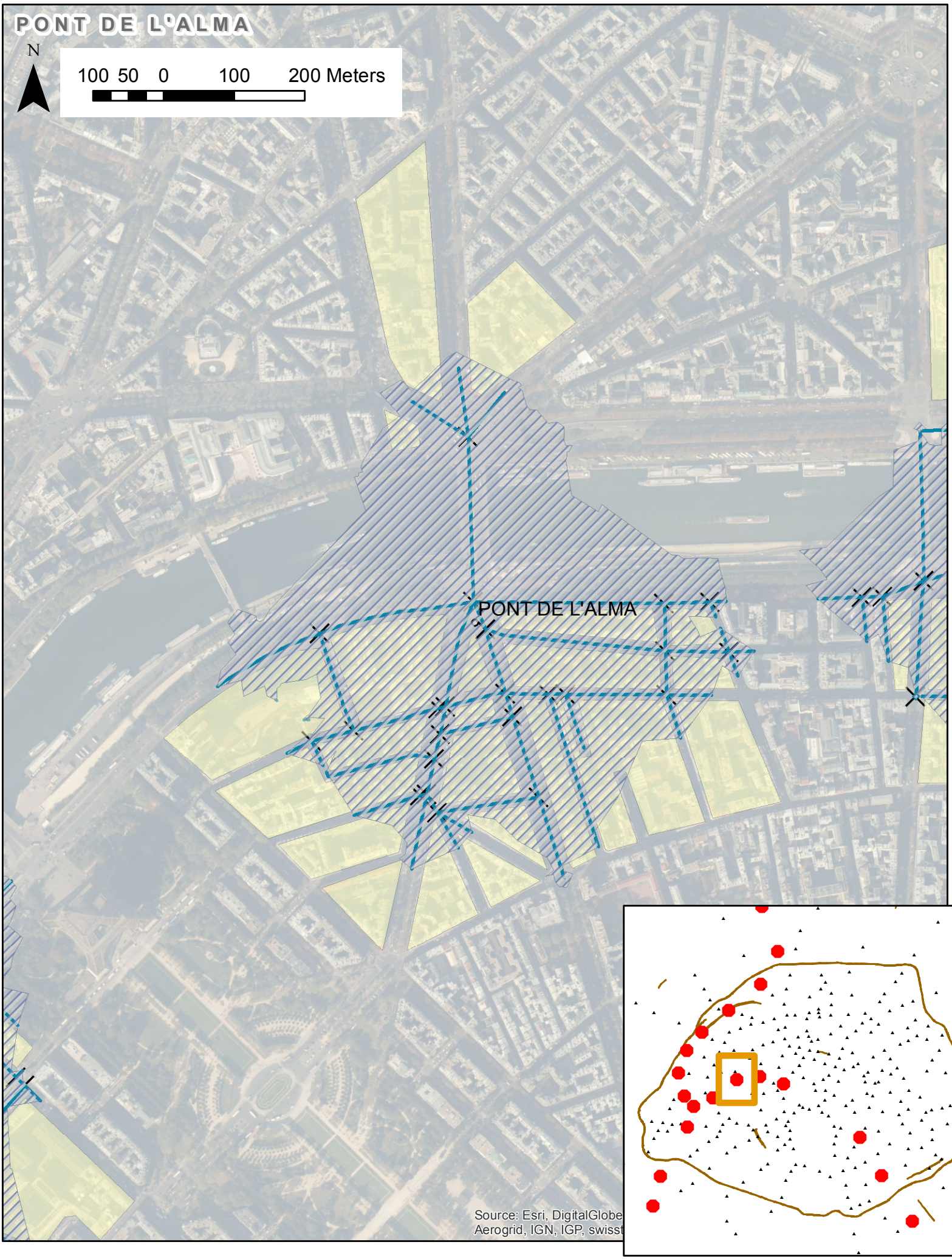
PARIS AUSTERLITZ (GARE D'AUSTERLITZ)
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


PEREIRE LEVALLOIS
N
100 50 0 100 200 Meters
PEREIRE LEVALLOIS
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst


PONT DE L'ALMA
N
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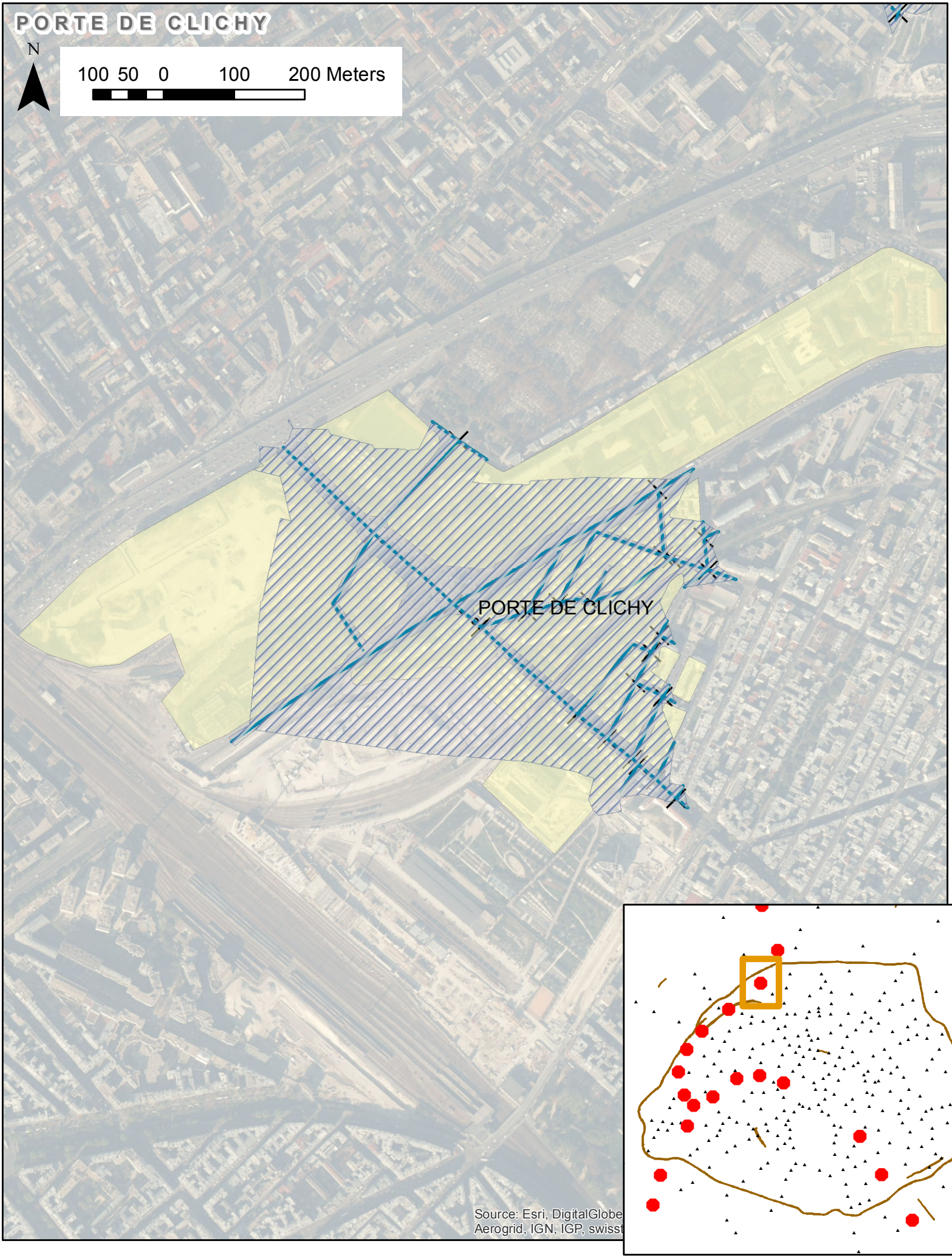
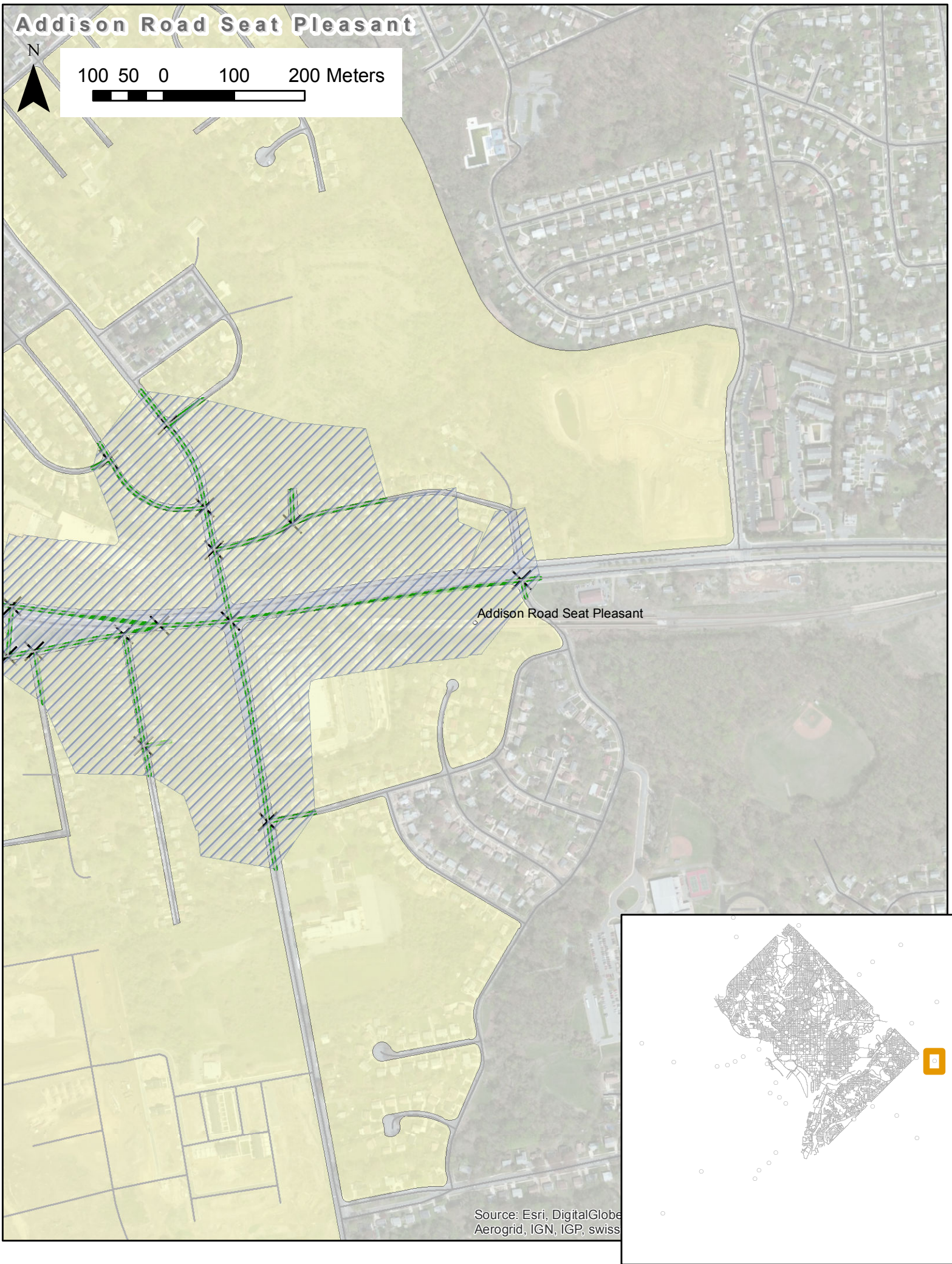
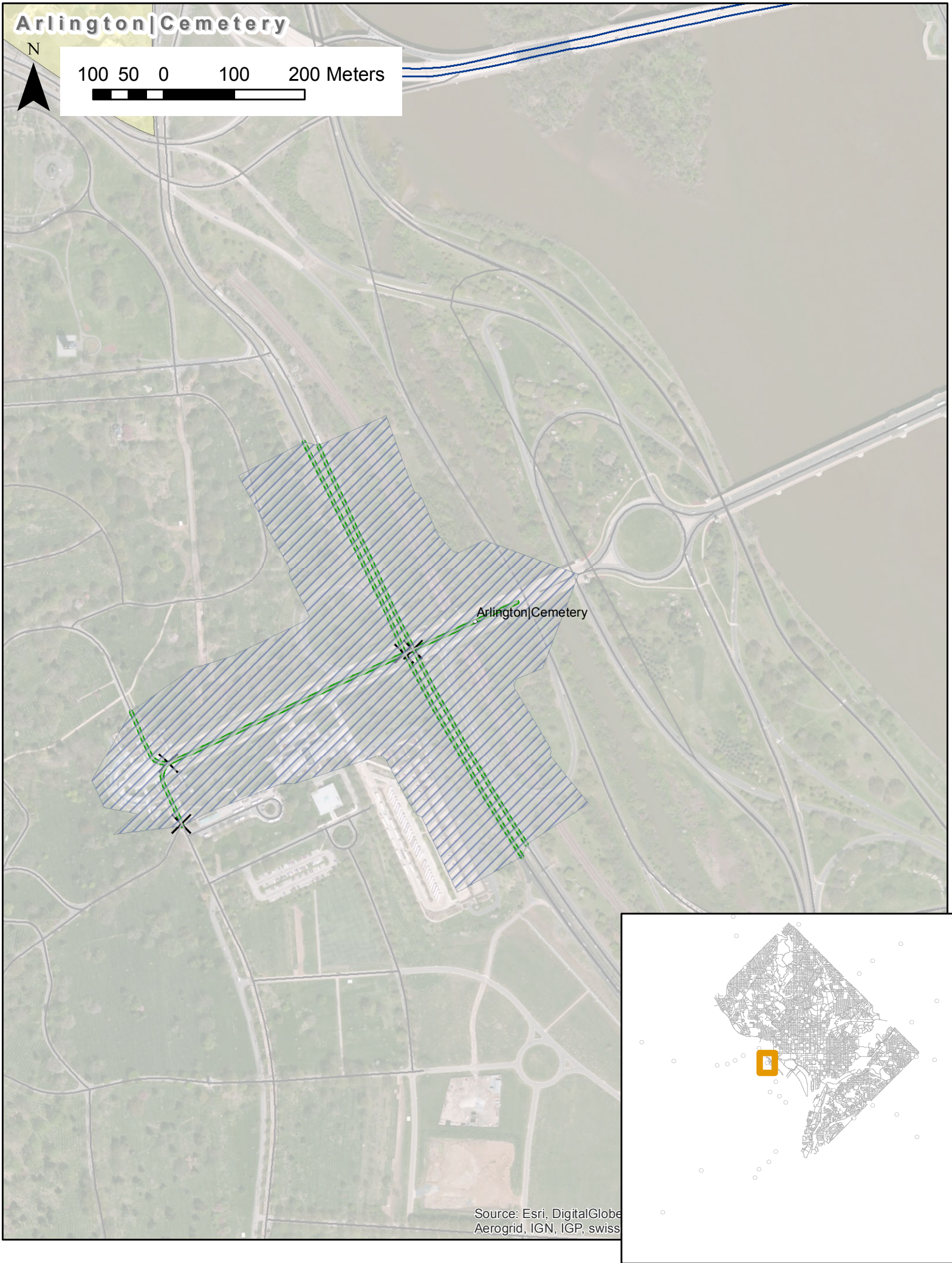
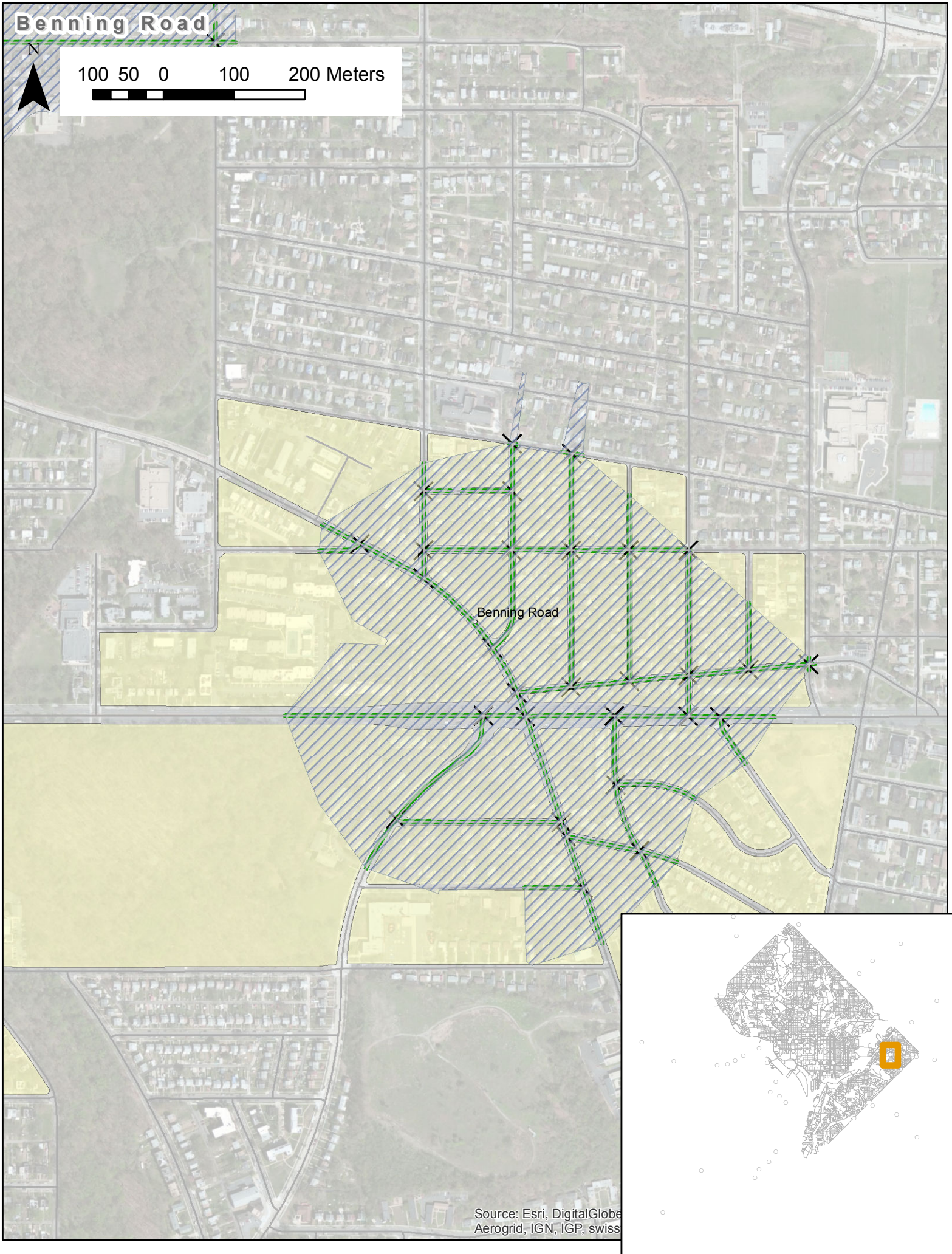
PONT DE L'ALMA
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst

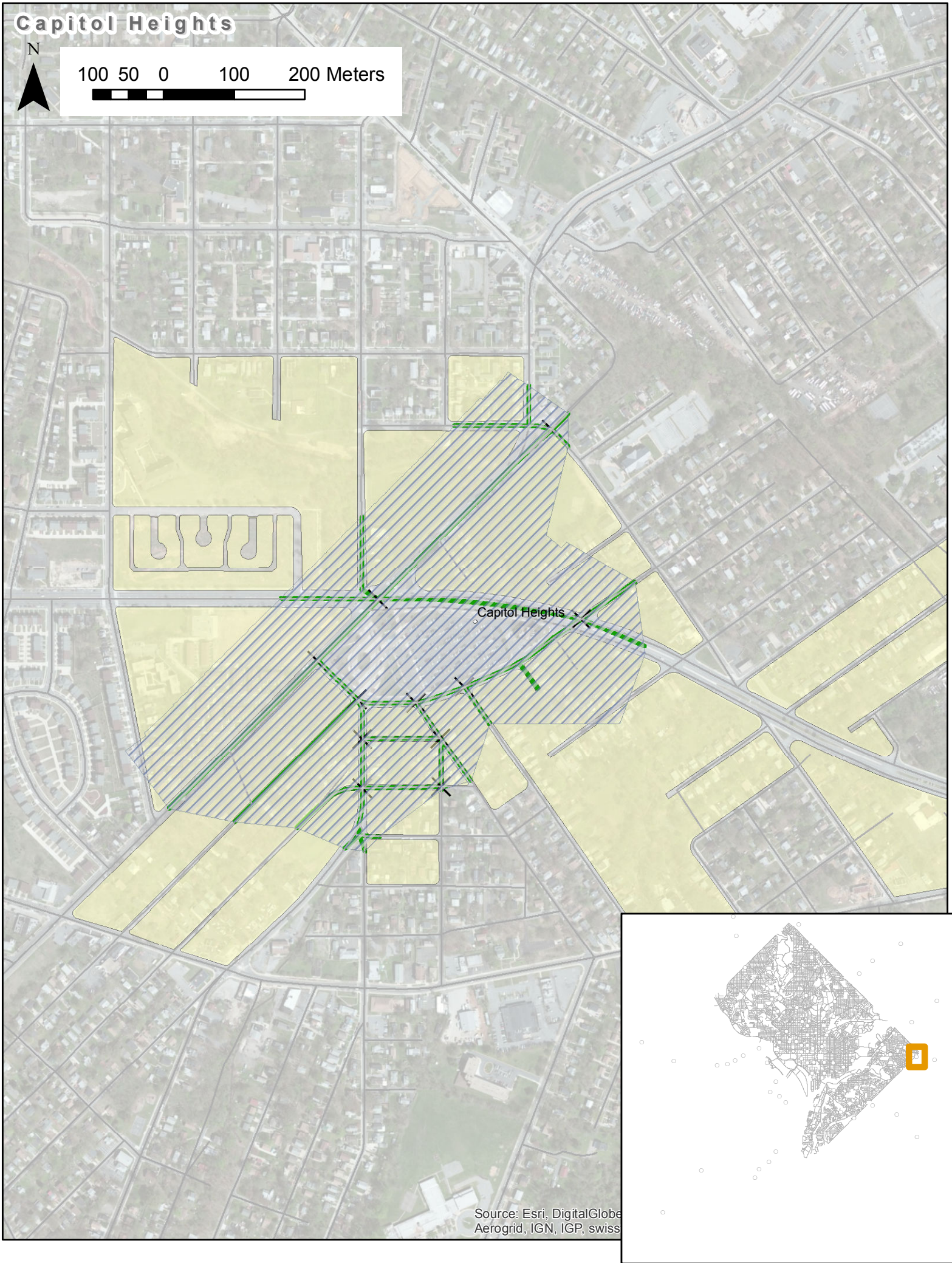

PORTE DE CLICHY
N
100 50 0 100 200 Meters
PORTE DE CLICHY
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swisst

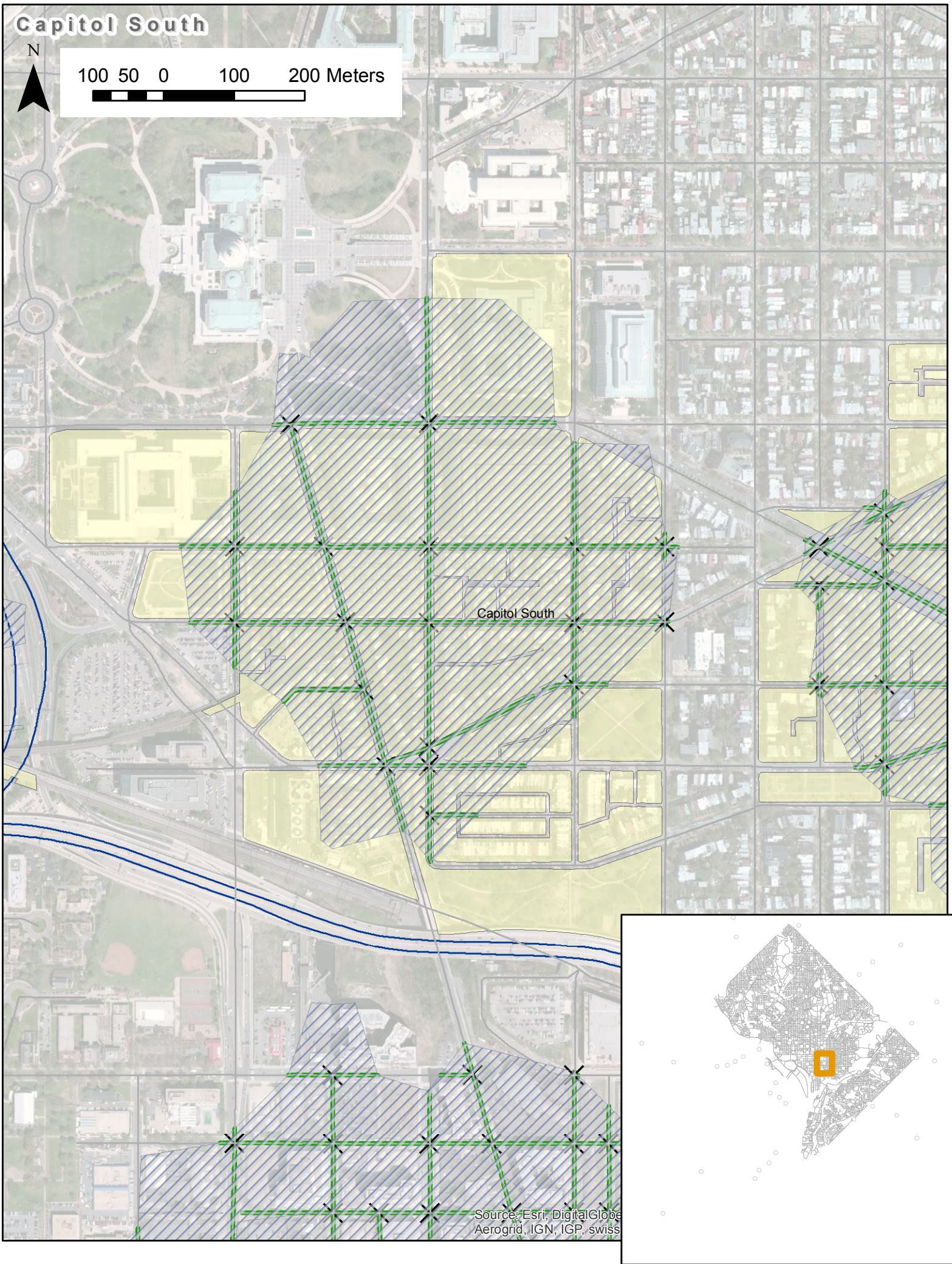

Addison Road Seat Pleasant
N
100 50 0 100 200 Meters
Addison Road Seat Pleasant
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

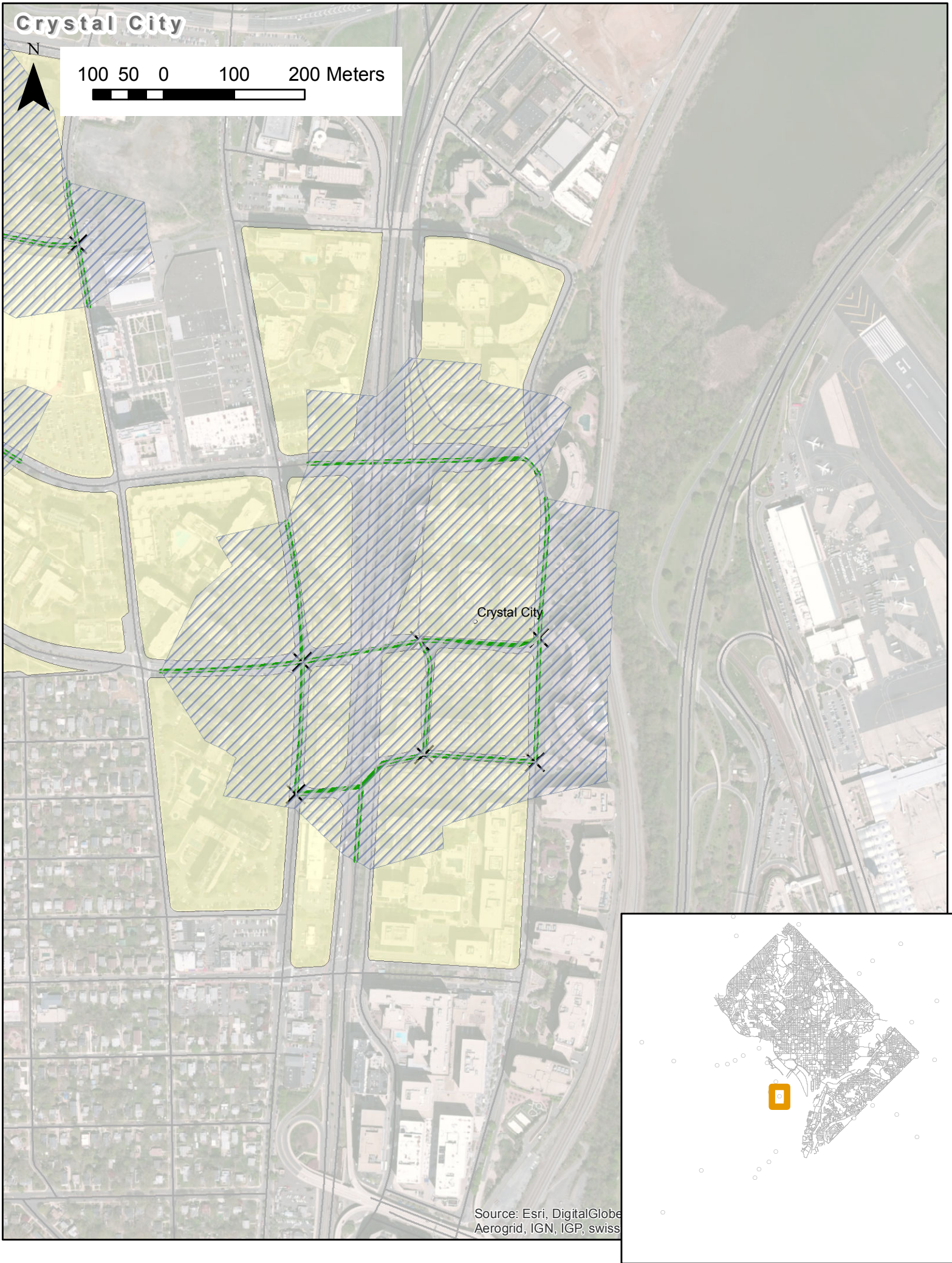

Arlington|Cemetery
N
100 50 0 100 200 Meters
Arlington|Cemetery
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss


Benning Road
N
100 50 0 100 200 Meters
Benning Road
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss


Braddock Road
N
100 50 0 100 200 Meters
Braddock Road
King St - Old Town
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss


Capitol Heights
N
100 50 0 100 200 Meters
Capitol Heights
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss


Capitol South
N
100 50 0 100 200 Meters
Capitol South
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss


Crystal City
N
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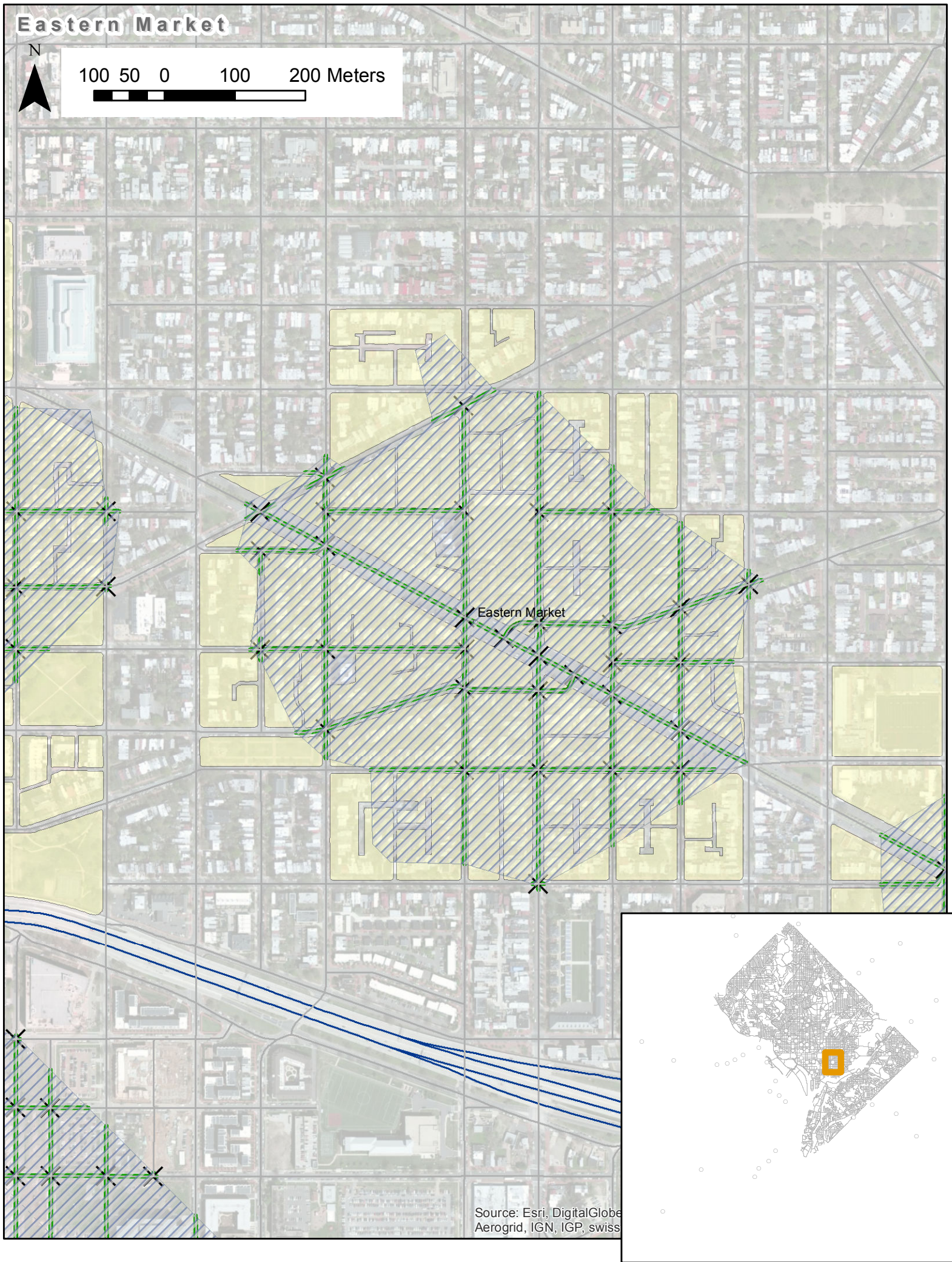
Crystal City
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss


Eastern Market
N
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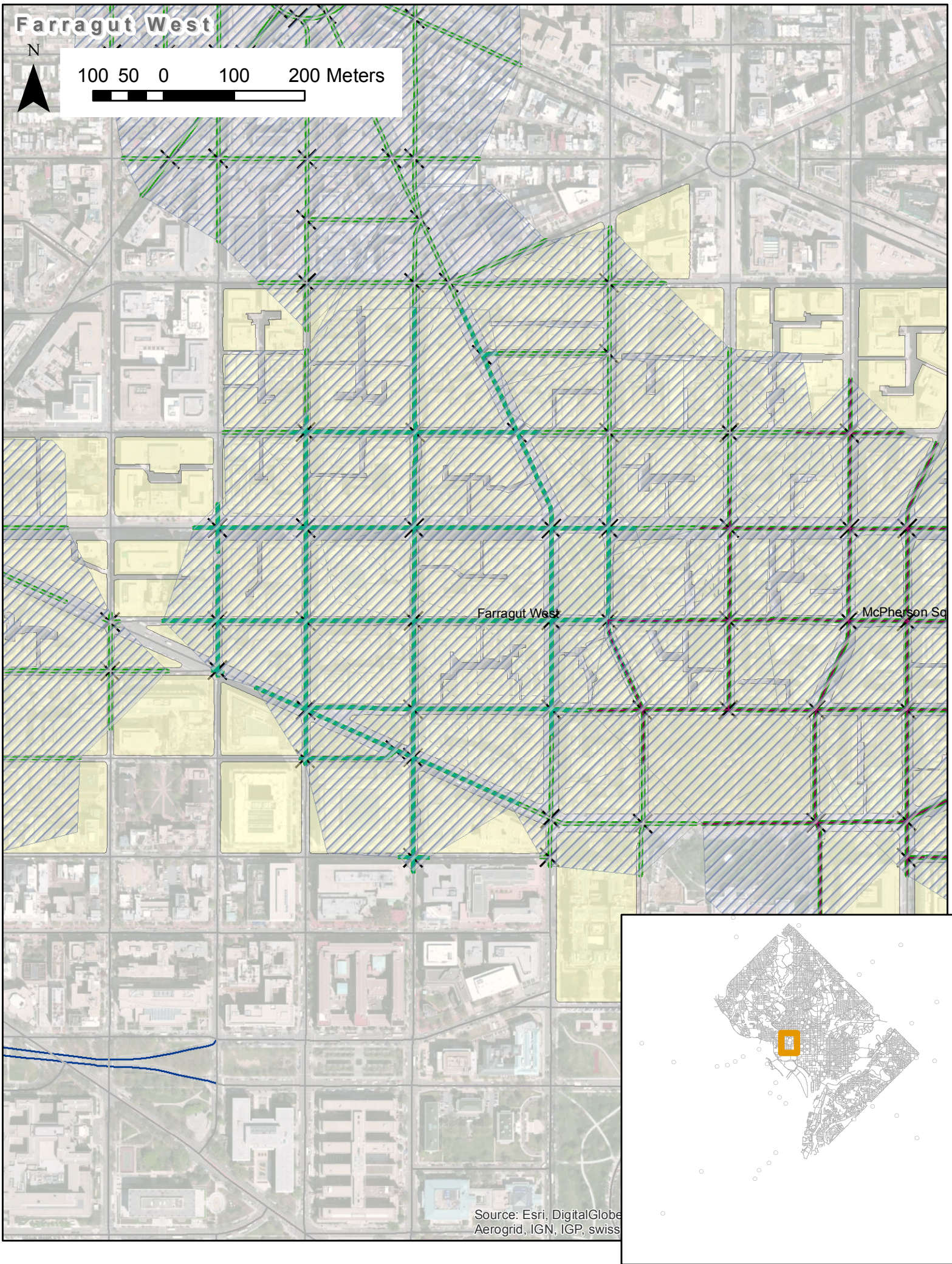
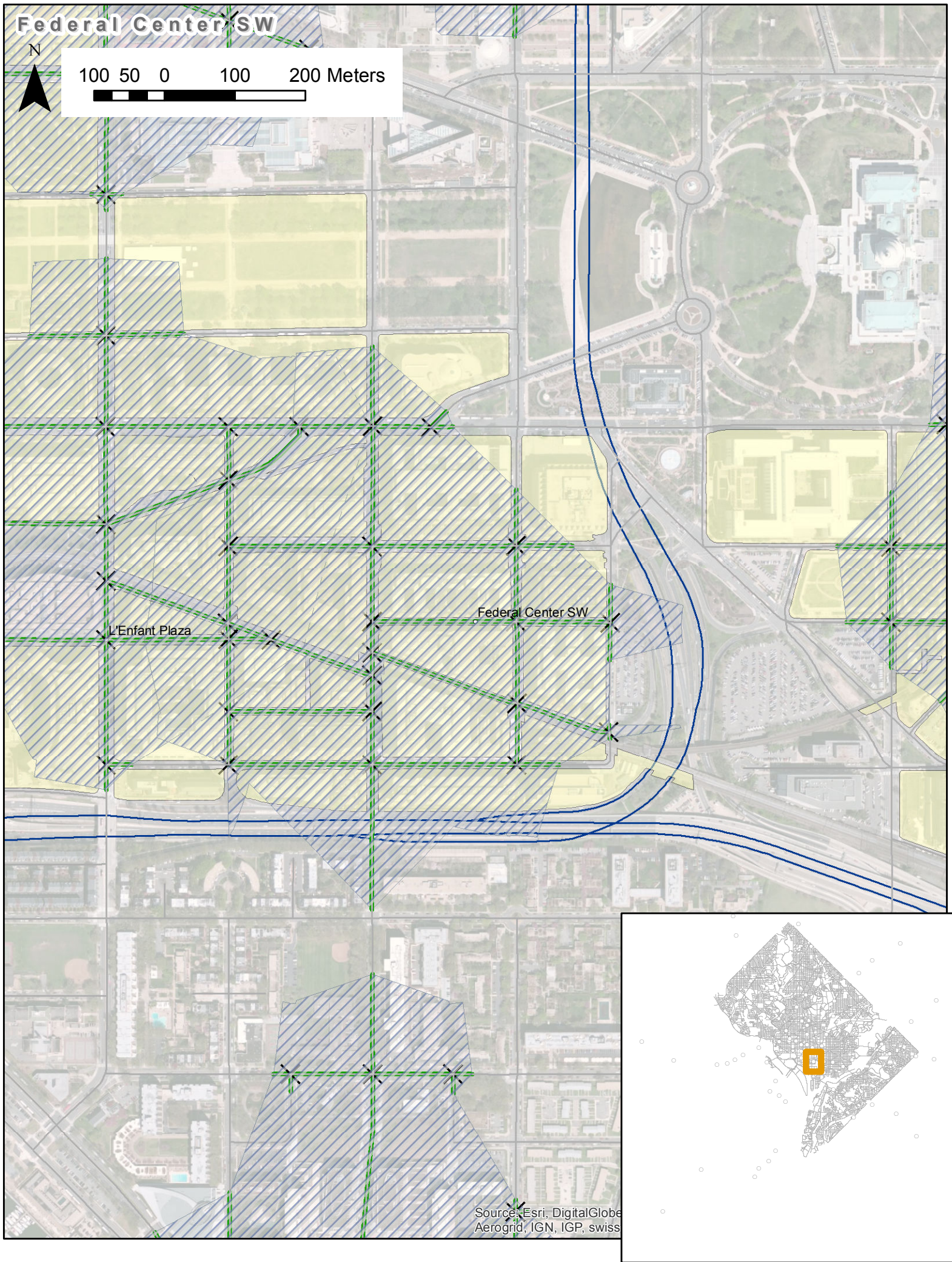
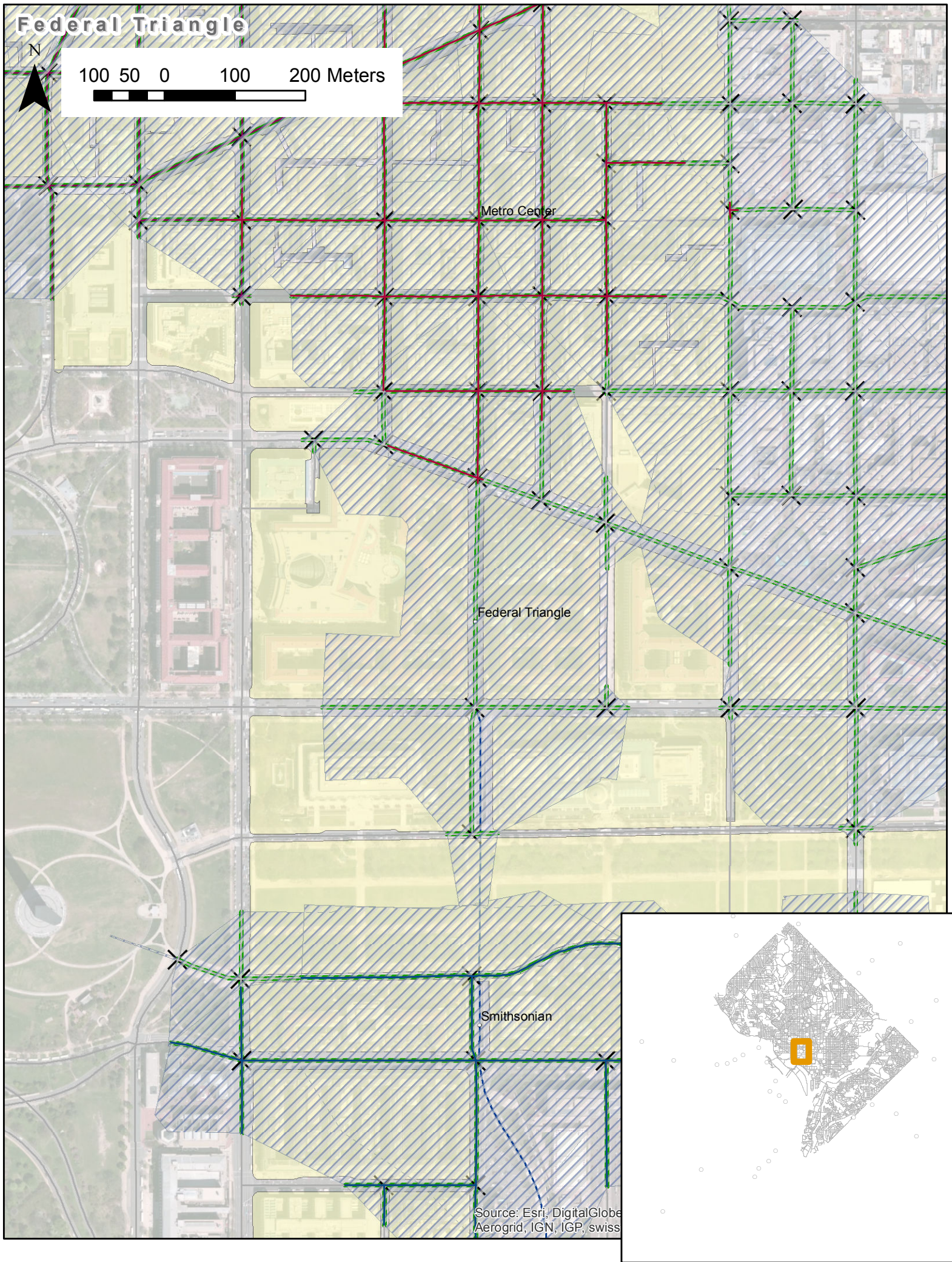
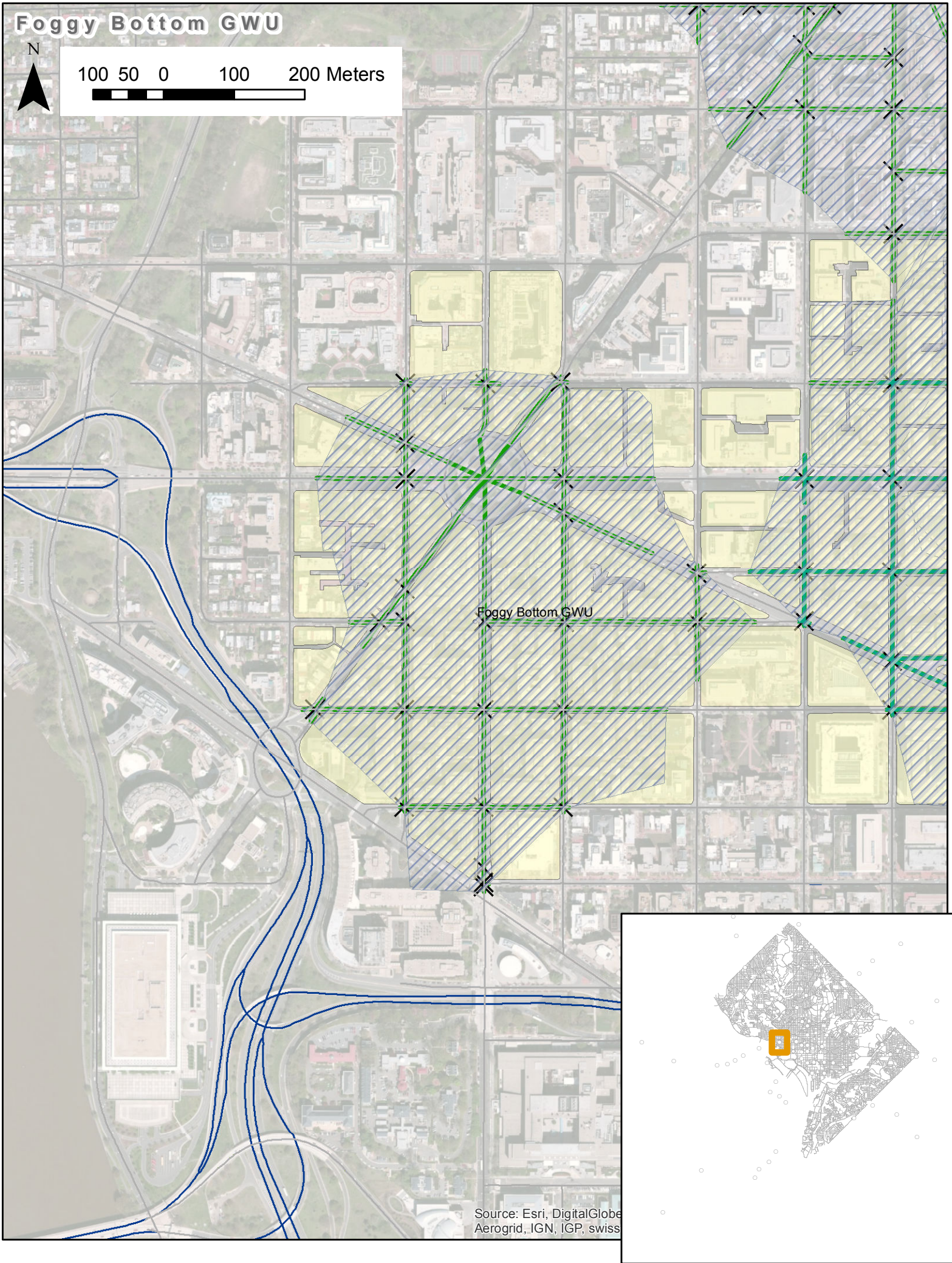
Eastern Market
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

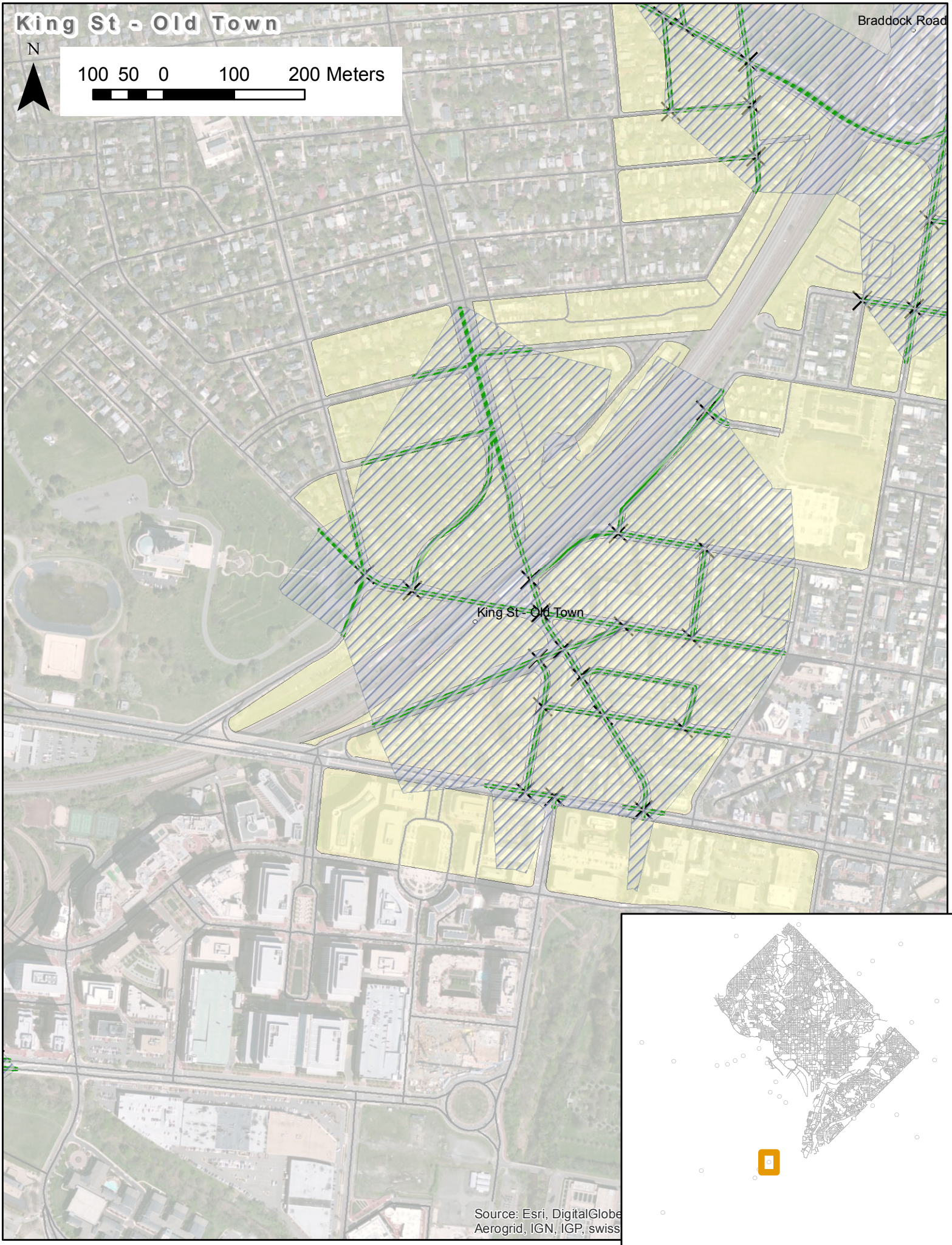

Farragut West
N
100 50 0 100 200 Meters
Farragut West
McPherson Sq
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

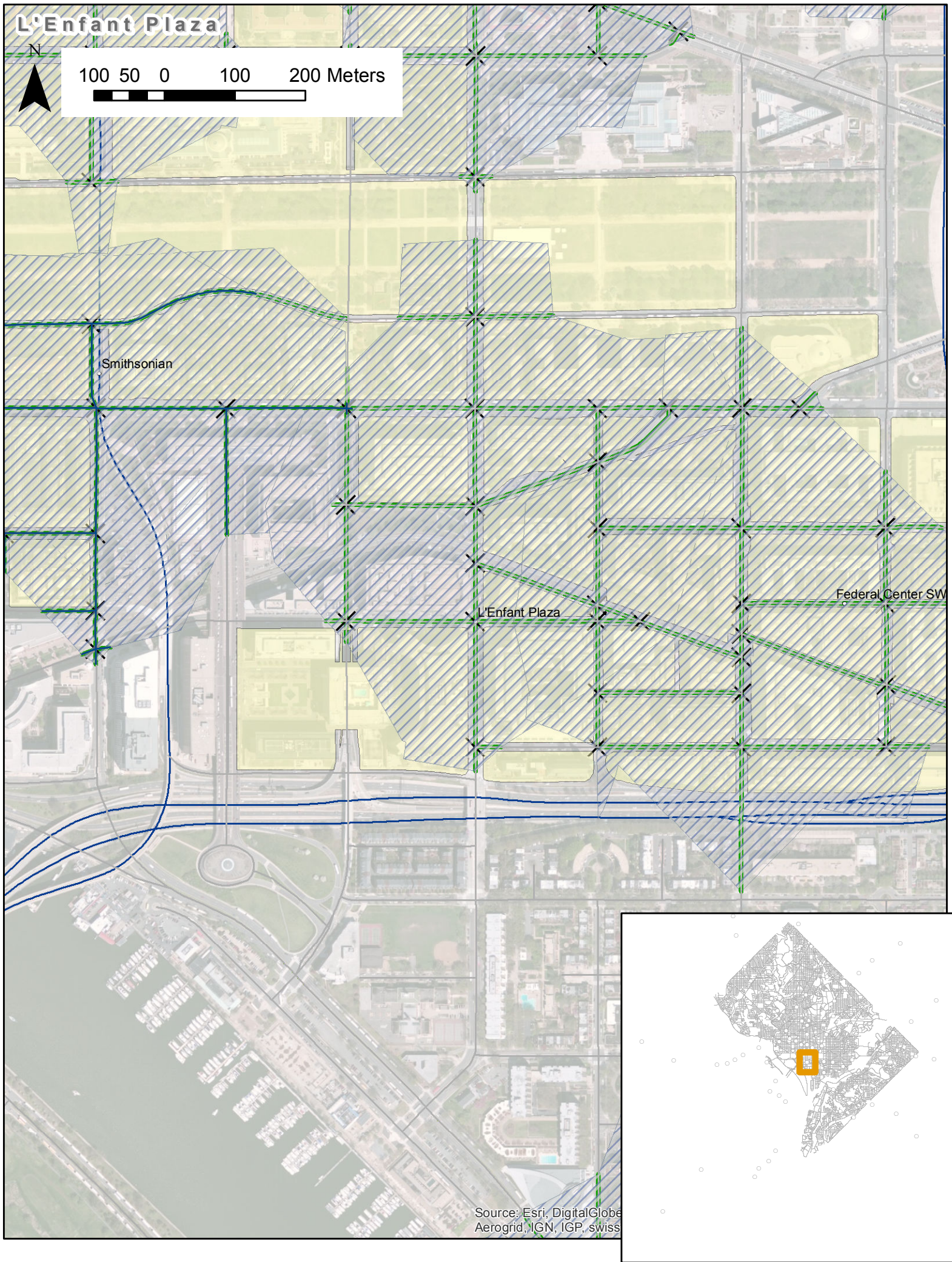

Federal Center SW
N
100 50 0 100 200 Meters
L'Enfant Plaza
Federal Center SW
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

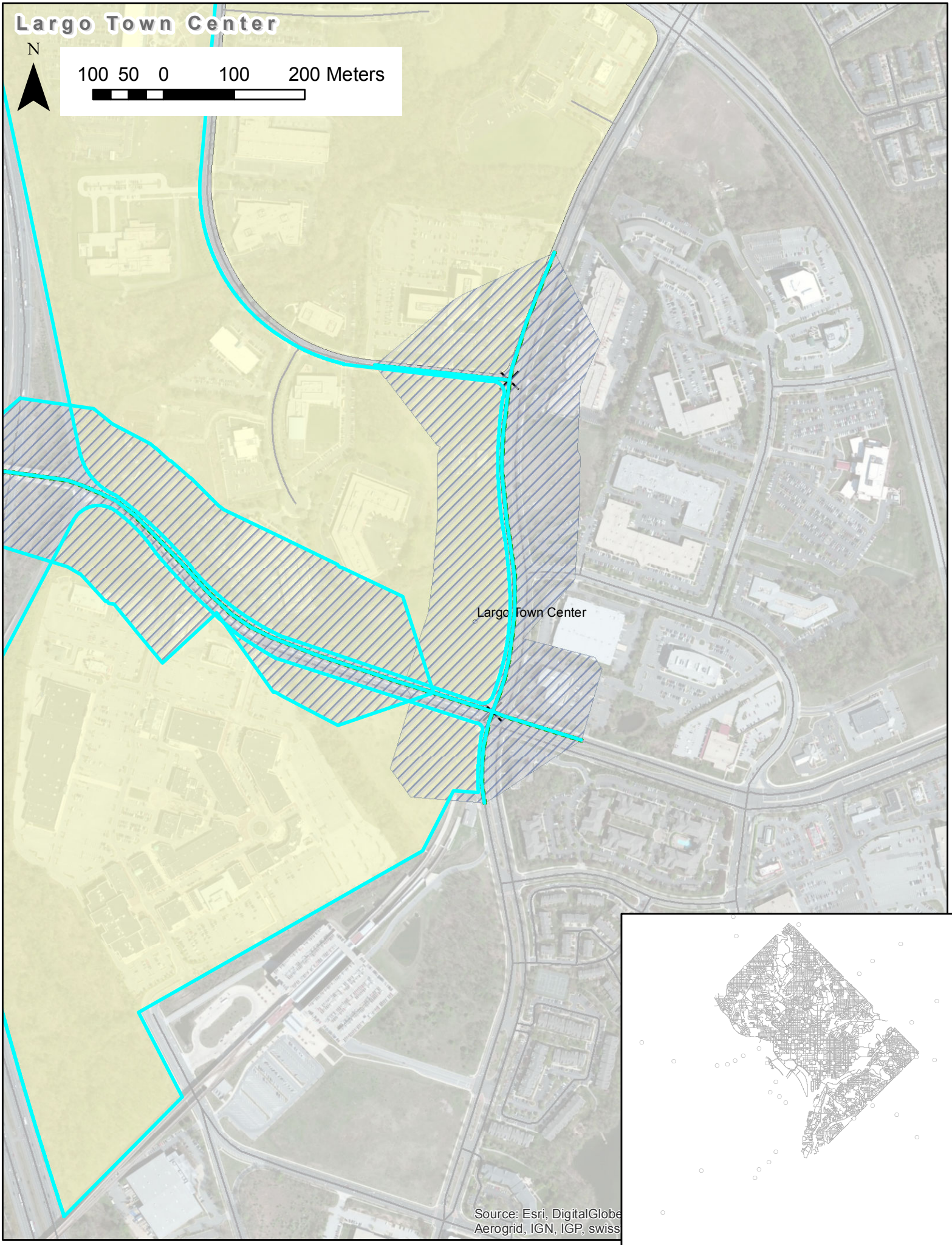

Federal Triangle
N
100 50 0 100 200 Meters
Metro Center
Federal Triangle
Smithsonian
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

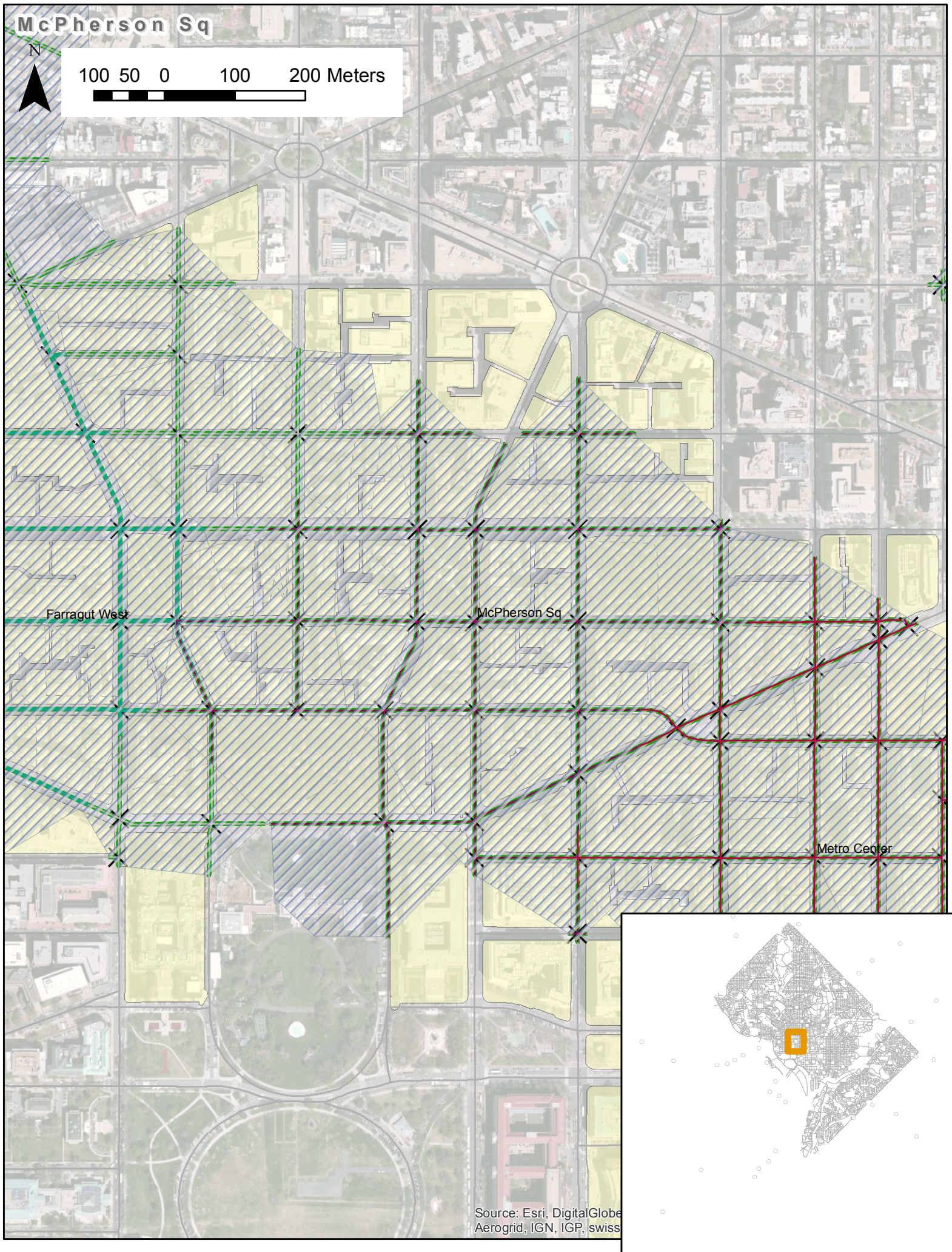

Foggy Bottom GWU
N
100 50 0 100 200 Meters
Foggy Bottom GWU
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

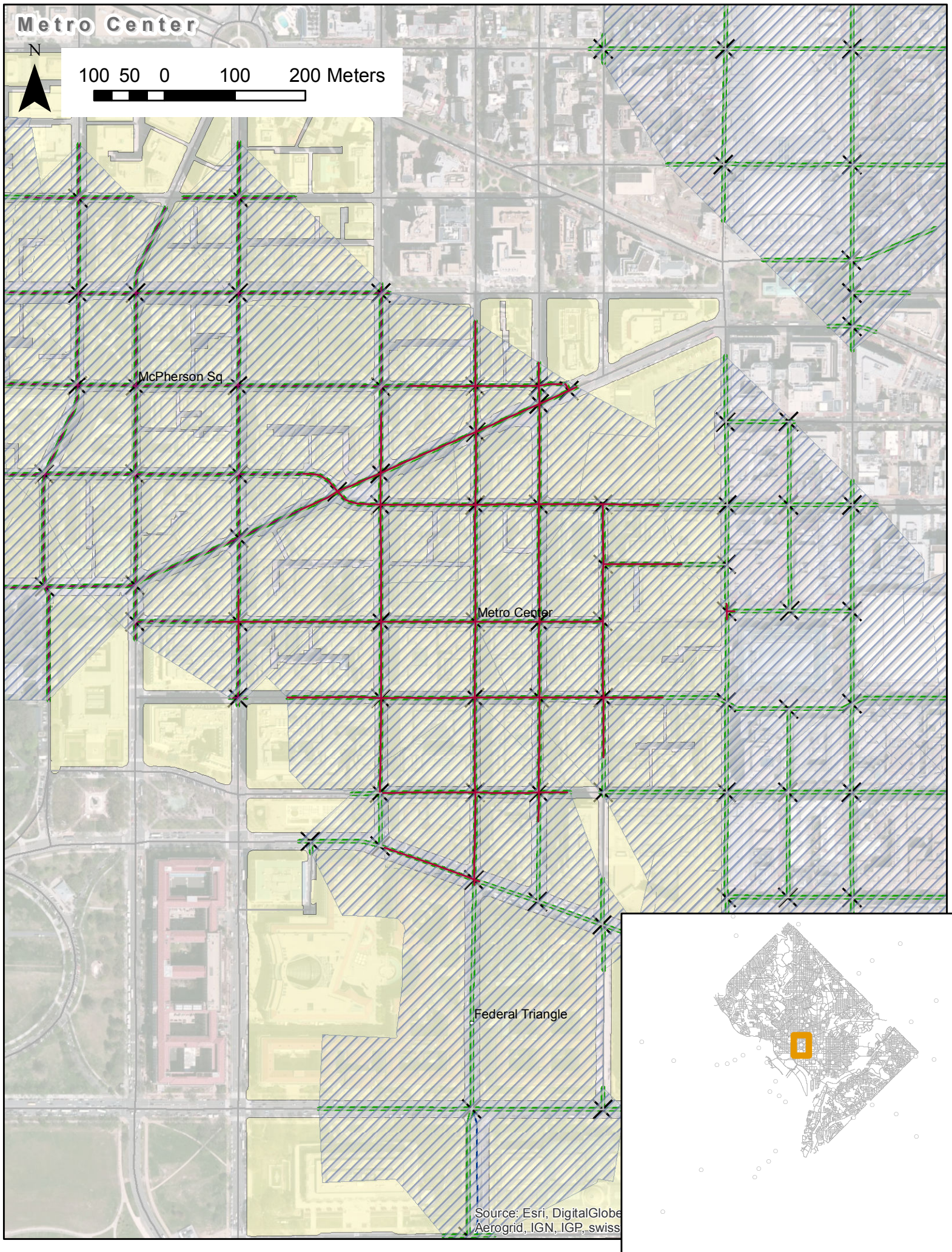

Franconia-Springfield
N
100 50 0 100 200 Meters
Franconia-Springfield
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss


King St - Old Town
N
100 50 0 100 200 Meters
Braddock Road
King St - Old Town
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

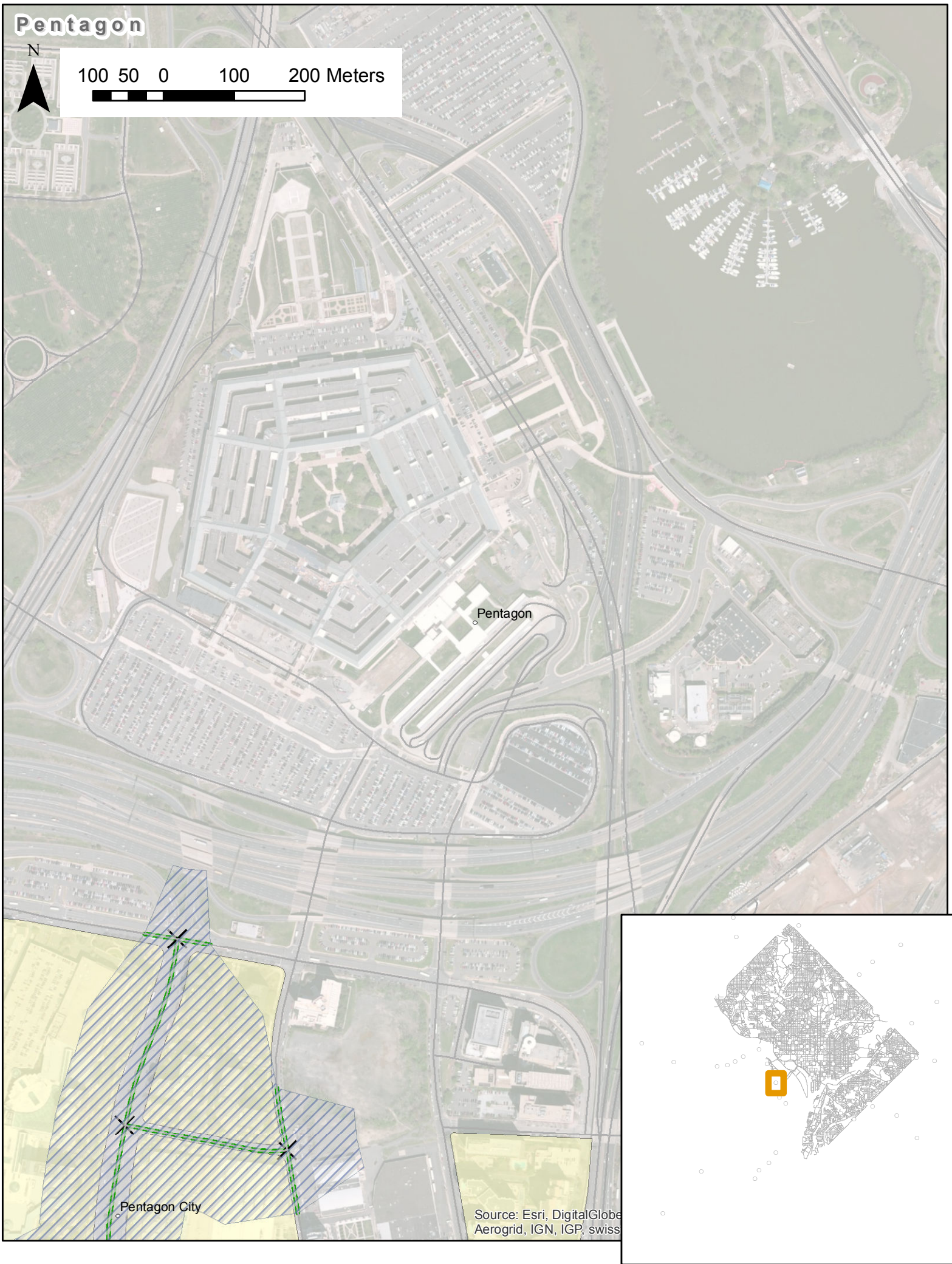

L'Enfant Plaza
N
100 50 0 100 200 Meters
Smithsonian
L'Enfant Plaza
Federal Center SW
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

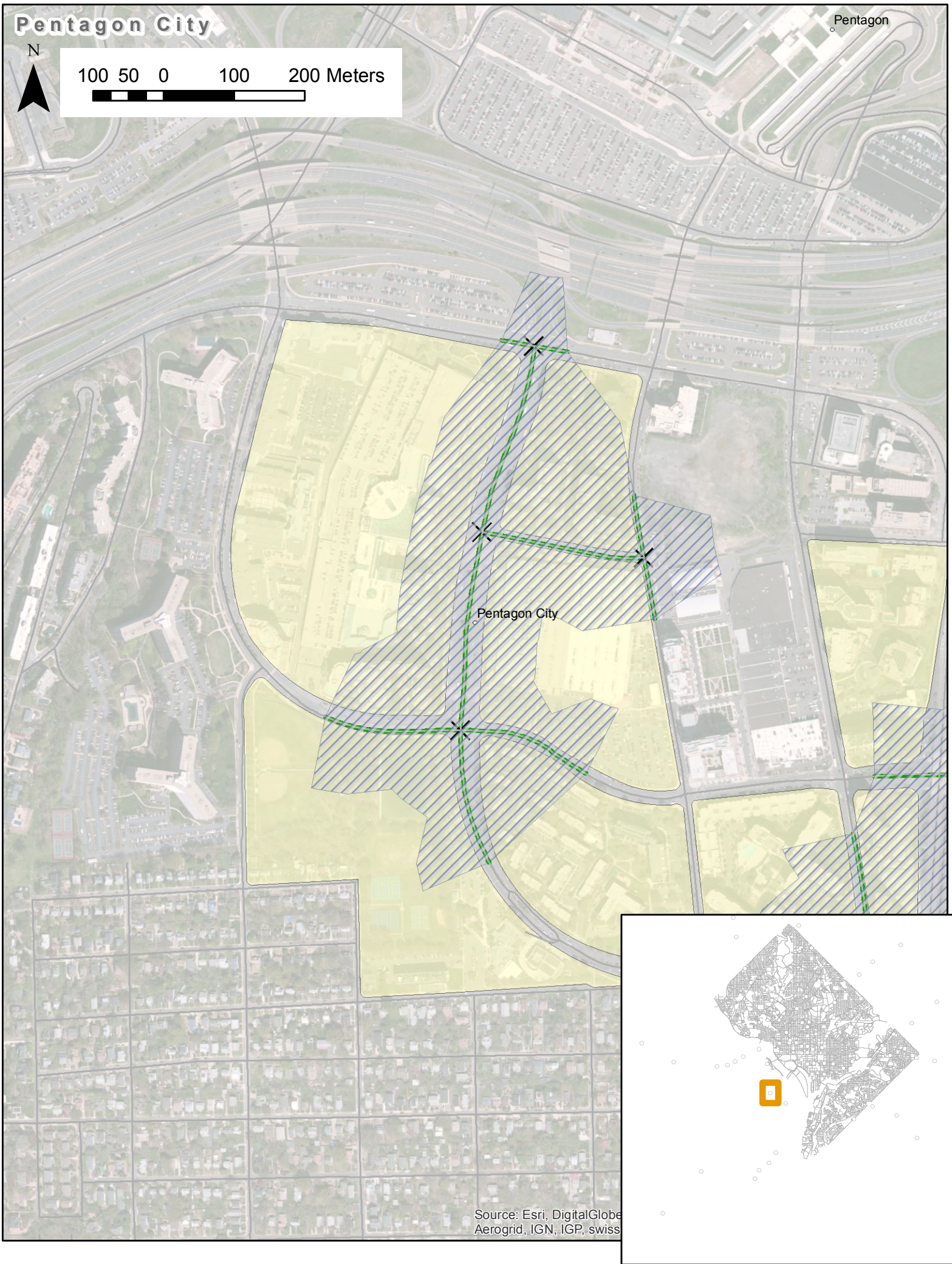

Largo Town Center
N
100 50 0 100 200 Meters
Largo Town Center
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

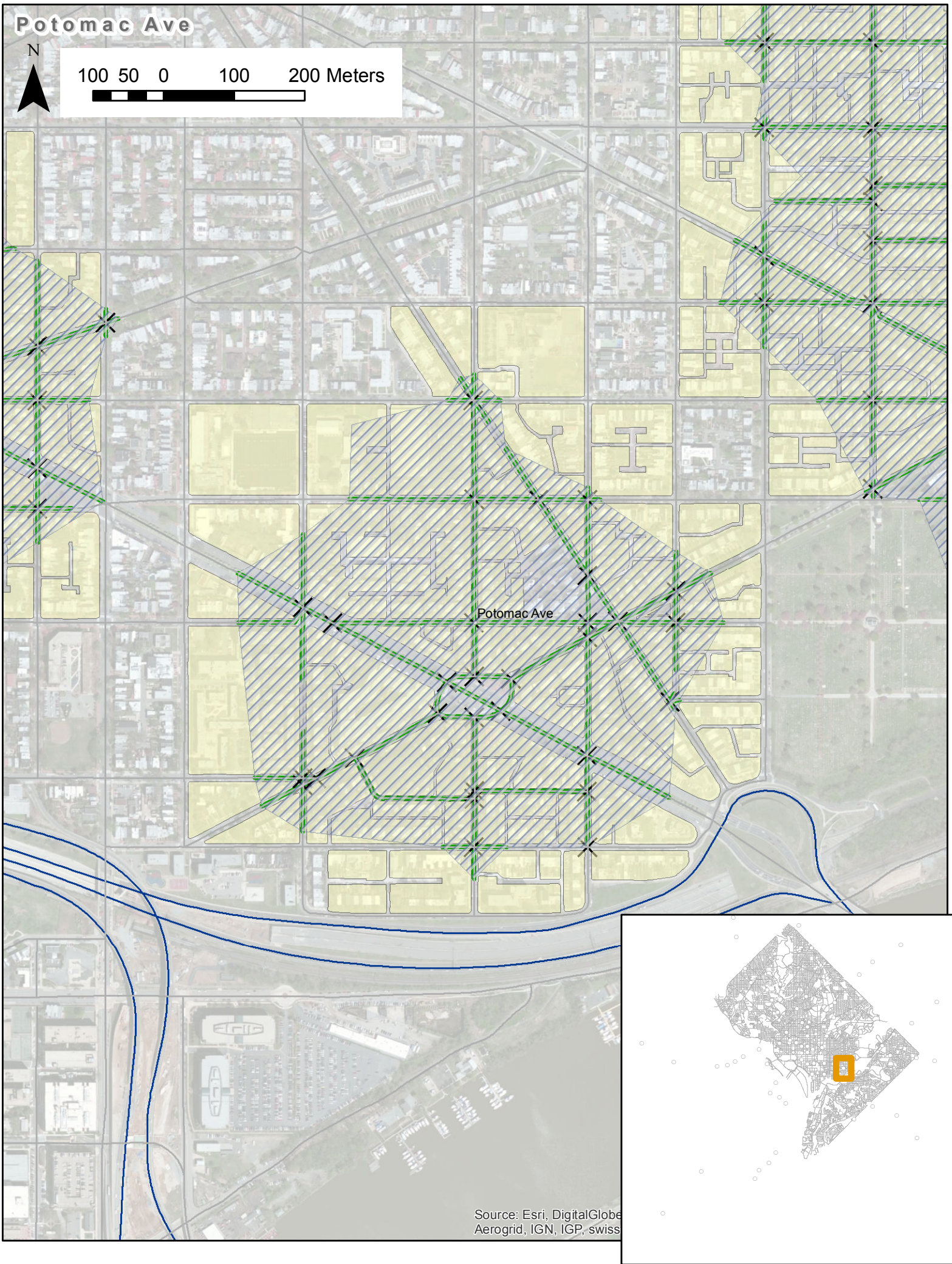

McPherson Sq
N
100 50 0 100 200 Meters
Farragut West
McPherson Sq
Metro Center
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

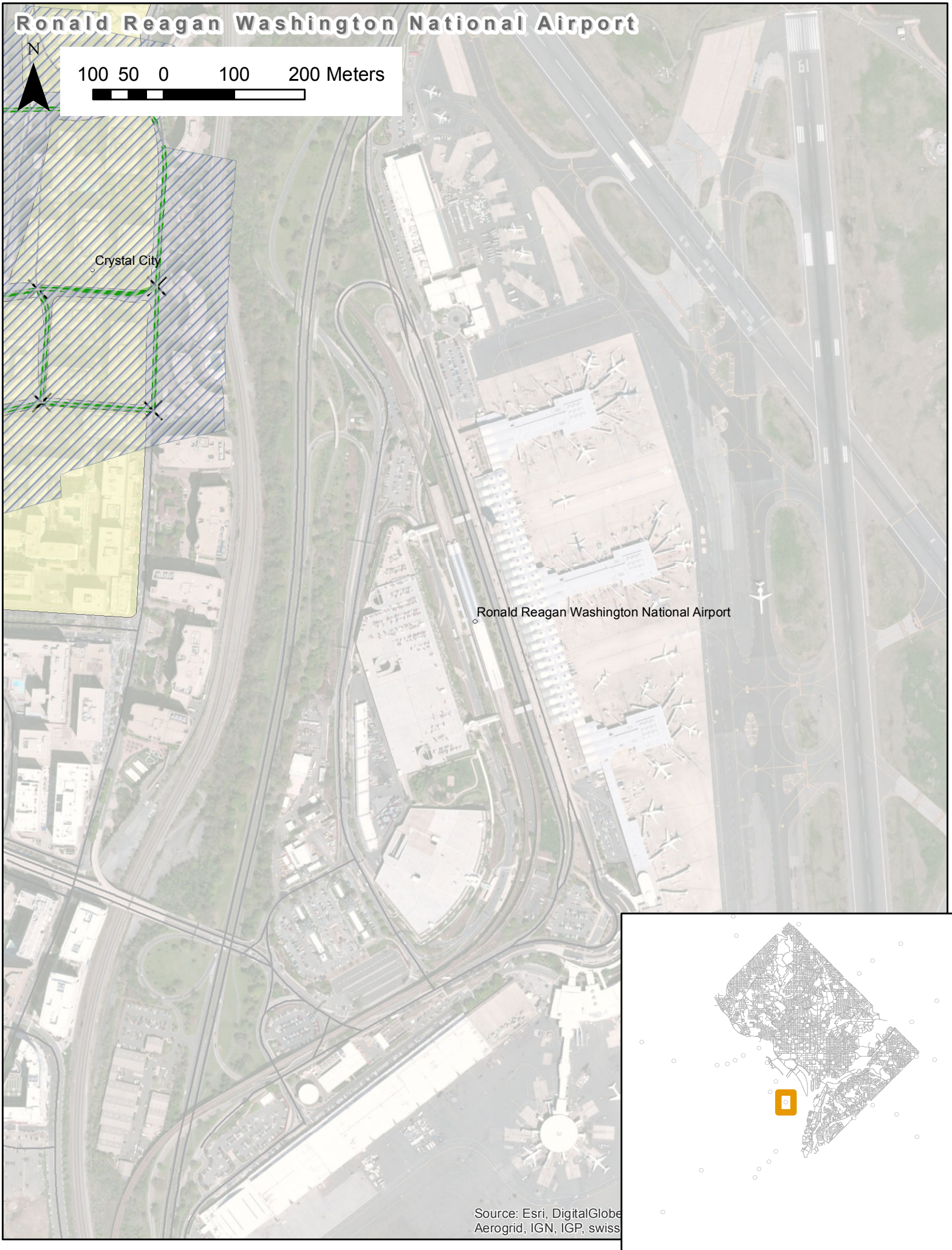

Metro Center
N
100 50 0 100 200 Meters
McPherson Sq
Metro Center
Federal Triangle
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

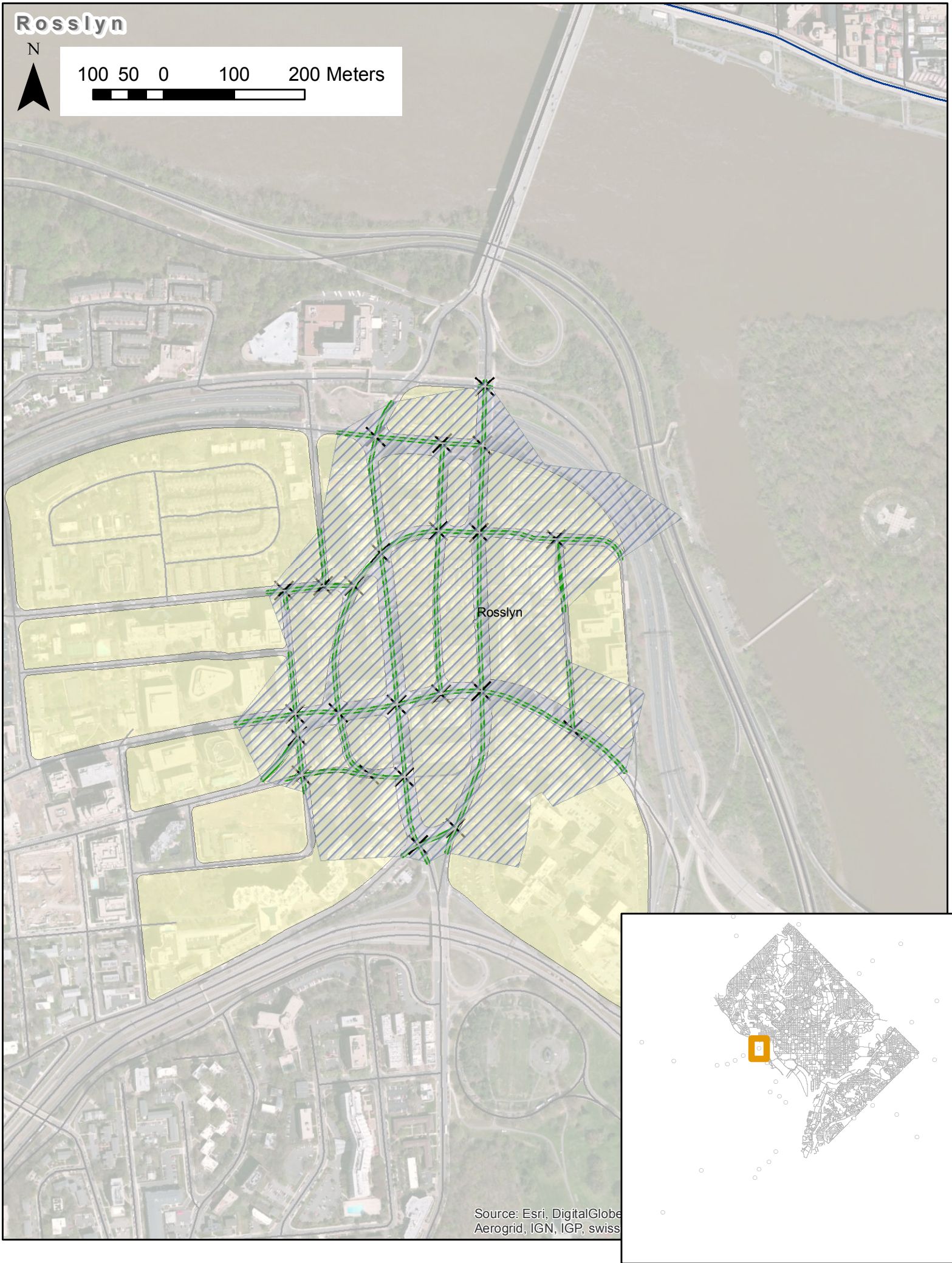

Morgan Boulevard
N
100 50 0 100 200 Meters
Morgan Boulevard
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

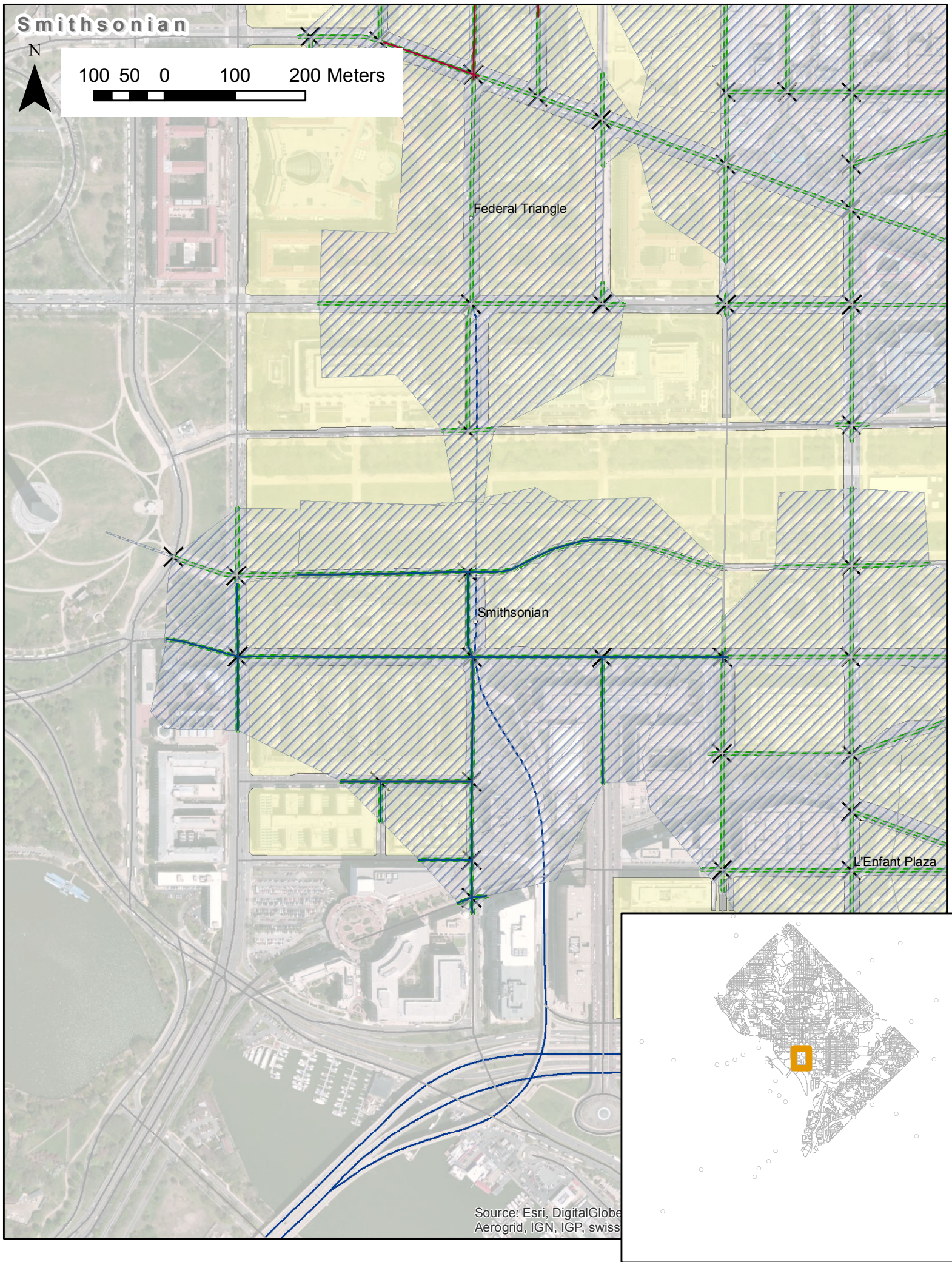

Pentagon
N
100 50 0 100 200 Meters
Pentagon
Pentagon City
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

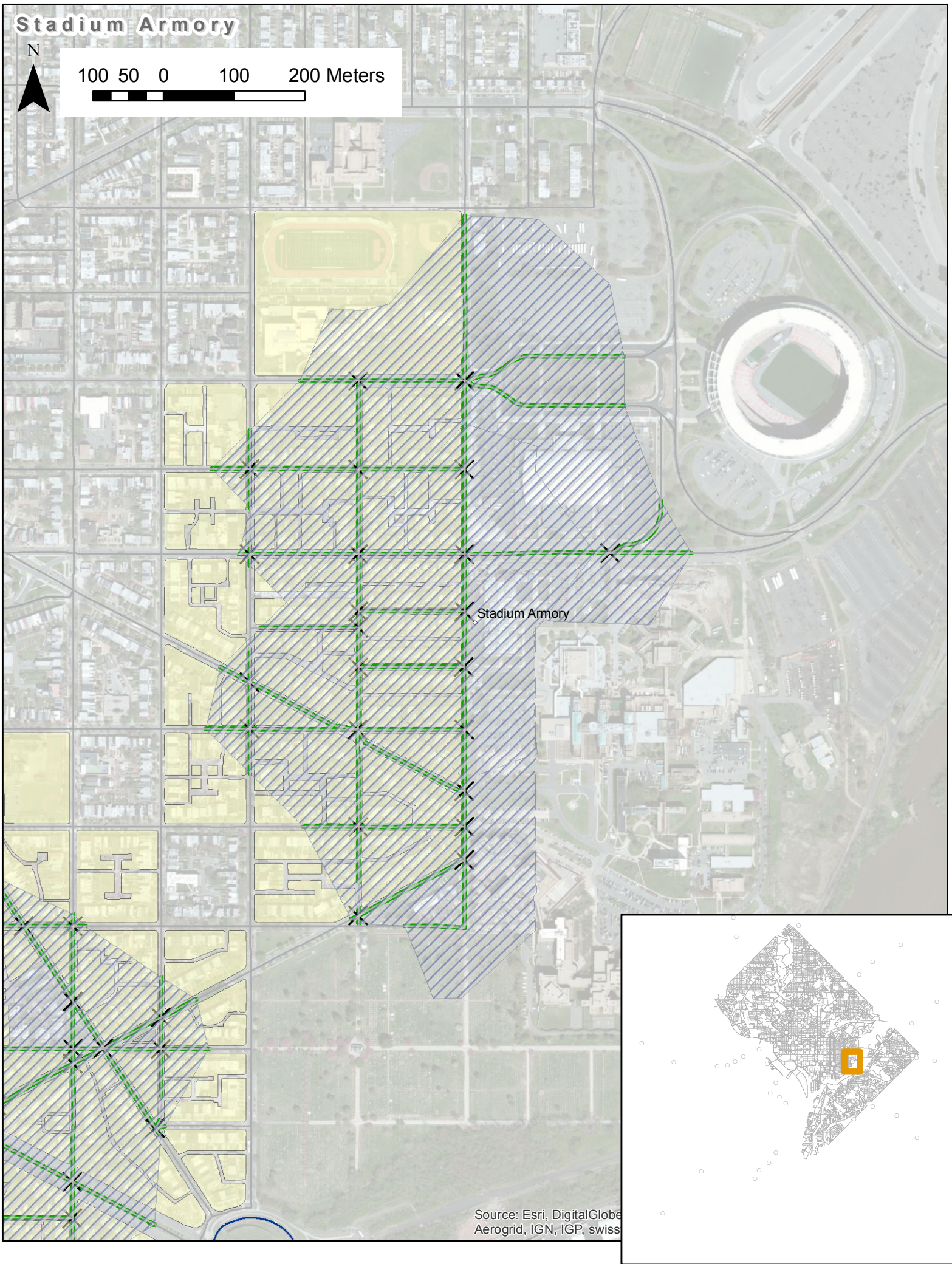

Pentagon City
N
100 50 0 100 200 Meters
Pentagon
Pentagon City
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

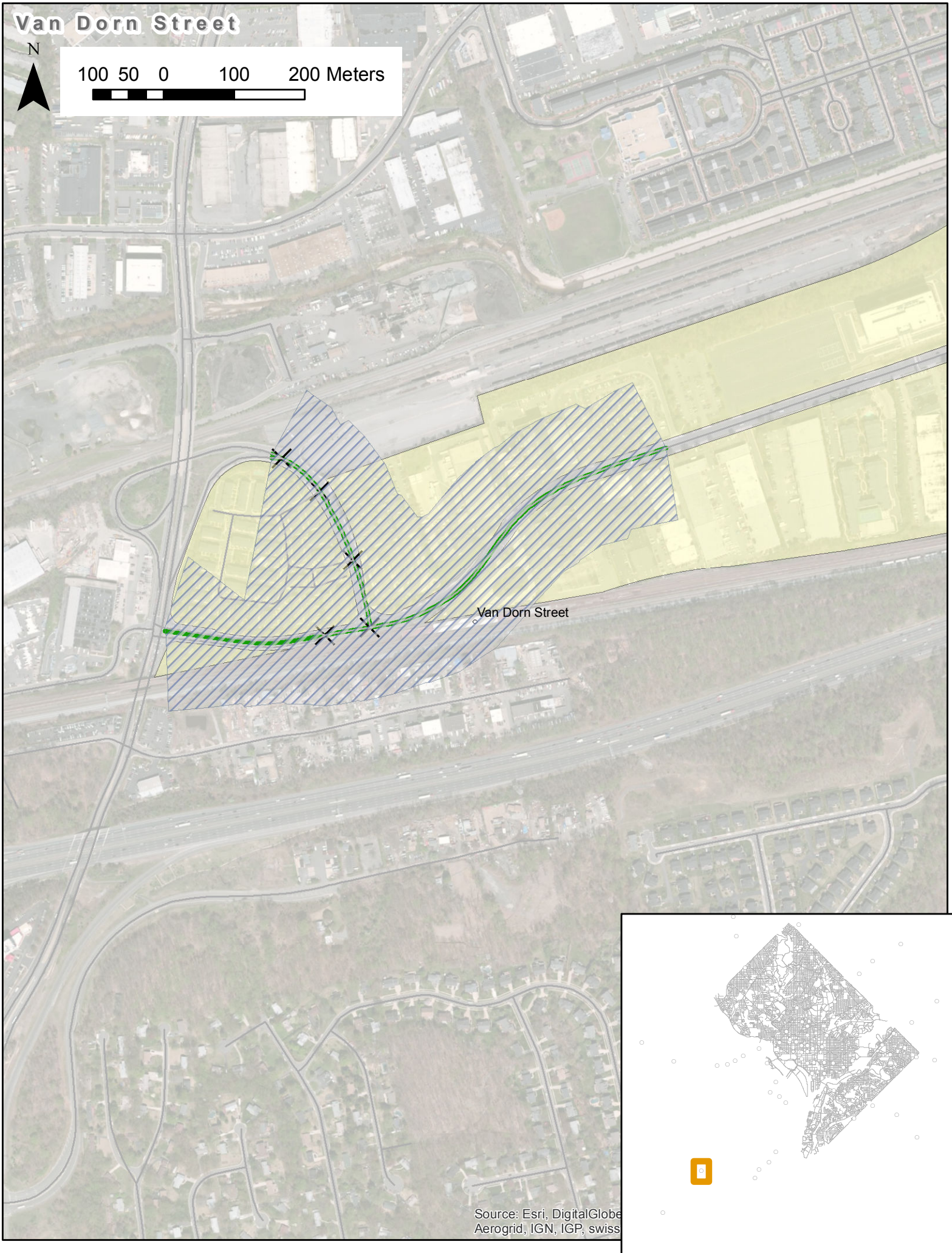

Potomac Ave
N
100 50 0 100 200 Meters
Potomac Ave
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

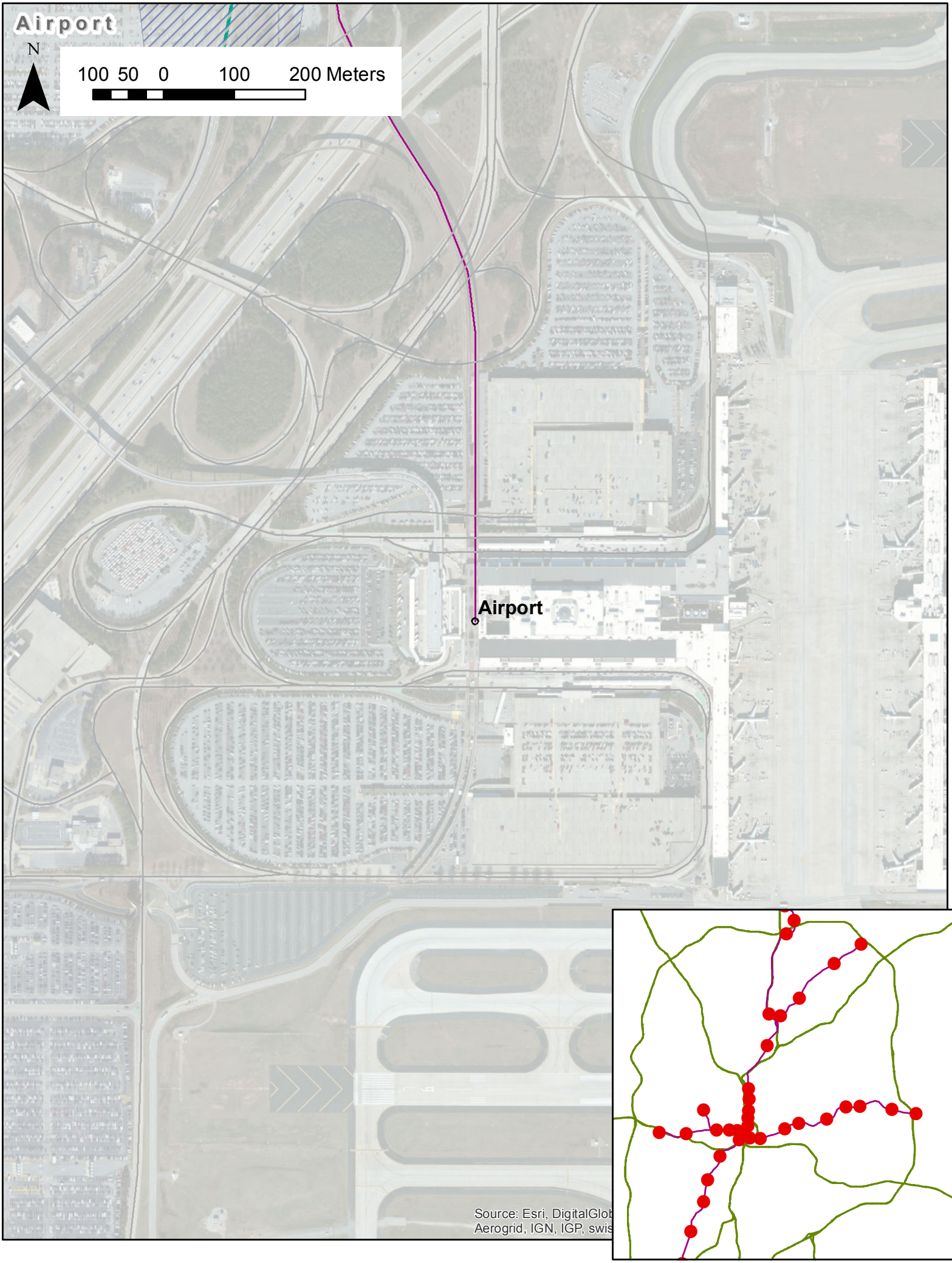

Ronald Reagan Washington National Airport
N
100 50 0 100 200 Meters
Crystal City
Ronald Reagan Washington National Airport
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

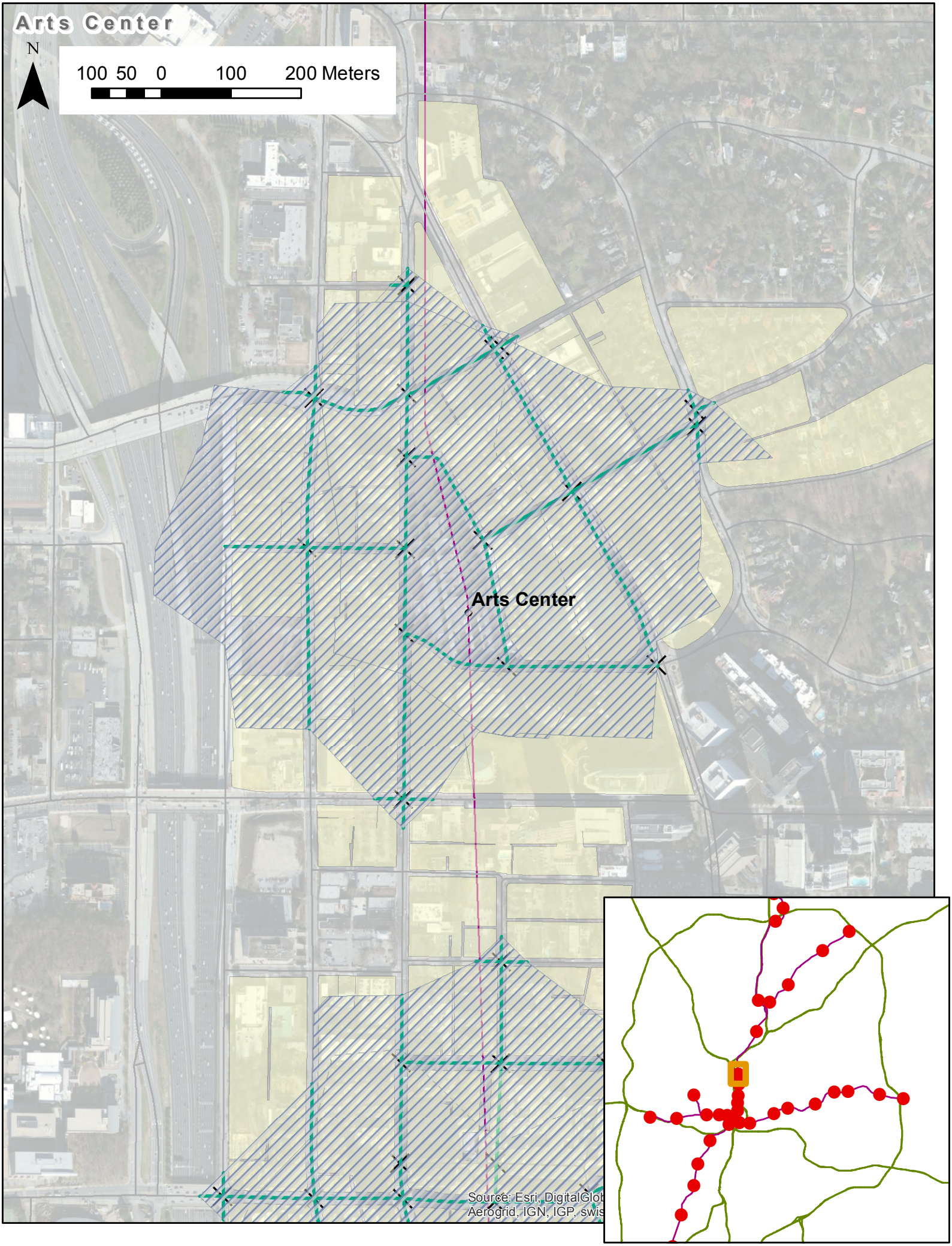

Rosslyn
N
100 50 0 100 200 Meters
Rosslyn
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

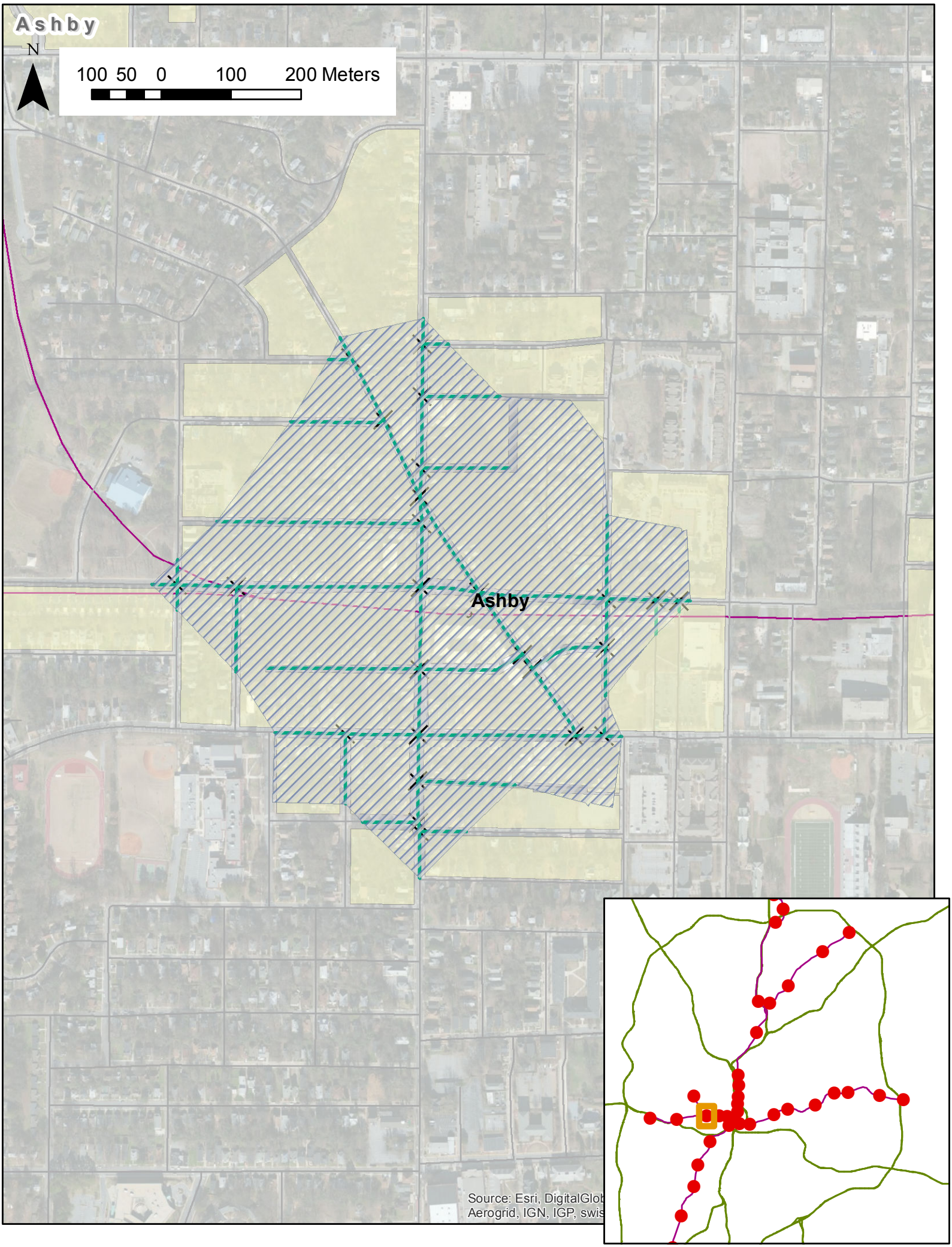

Smithsonian
N
100 50 0 100 200 Meters
Federal Triangle
Smithsonian
L'Enfant Plaza
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

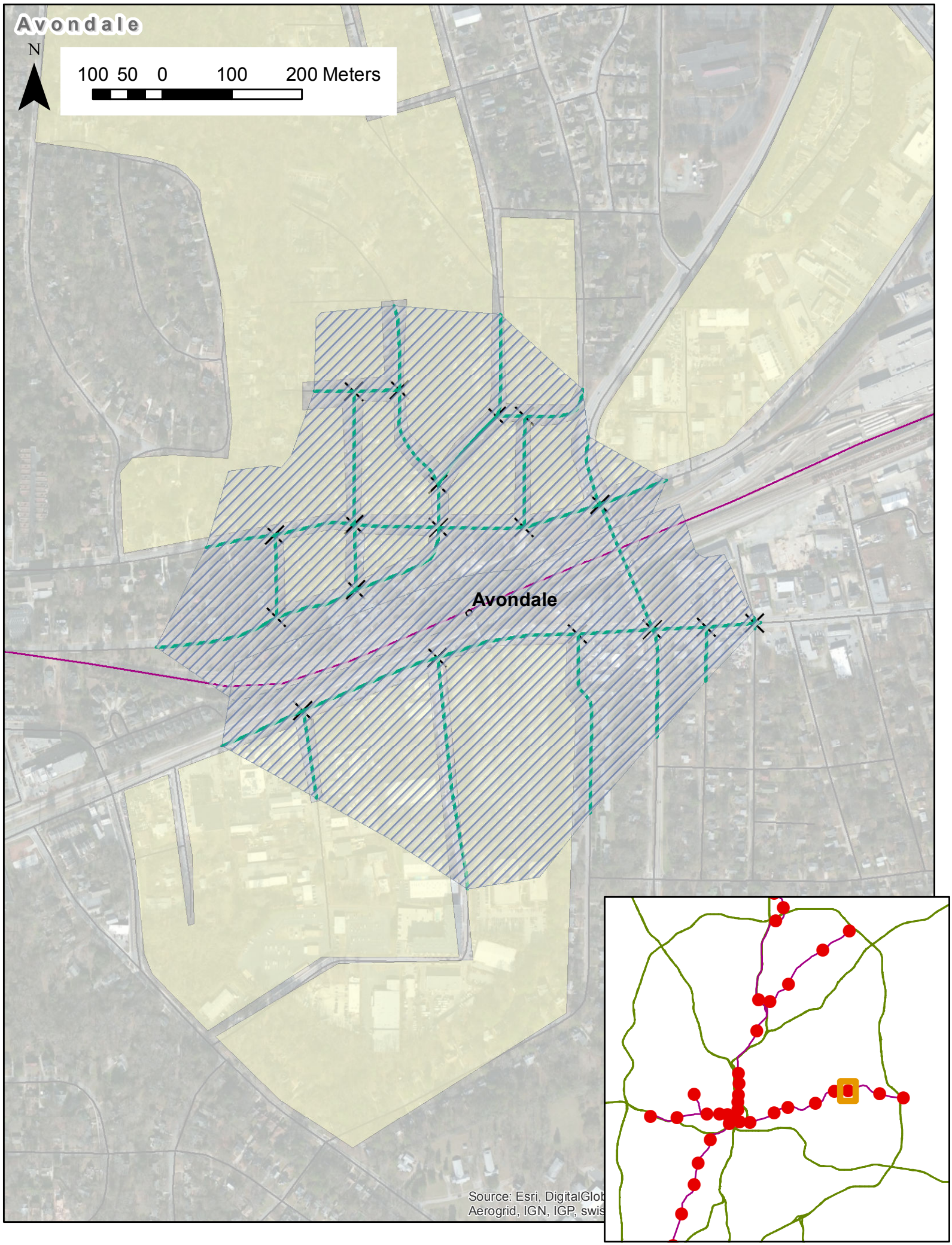

Stadium Armory
N
100 50 0 100 200 Meters
Stadium Armory
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

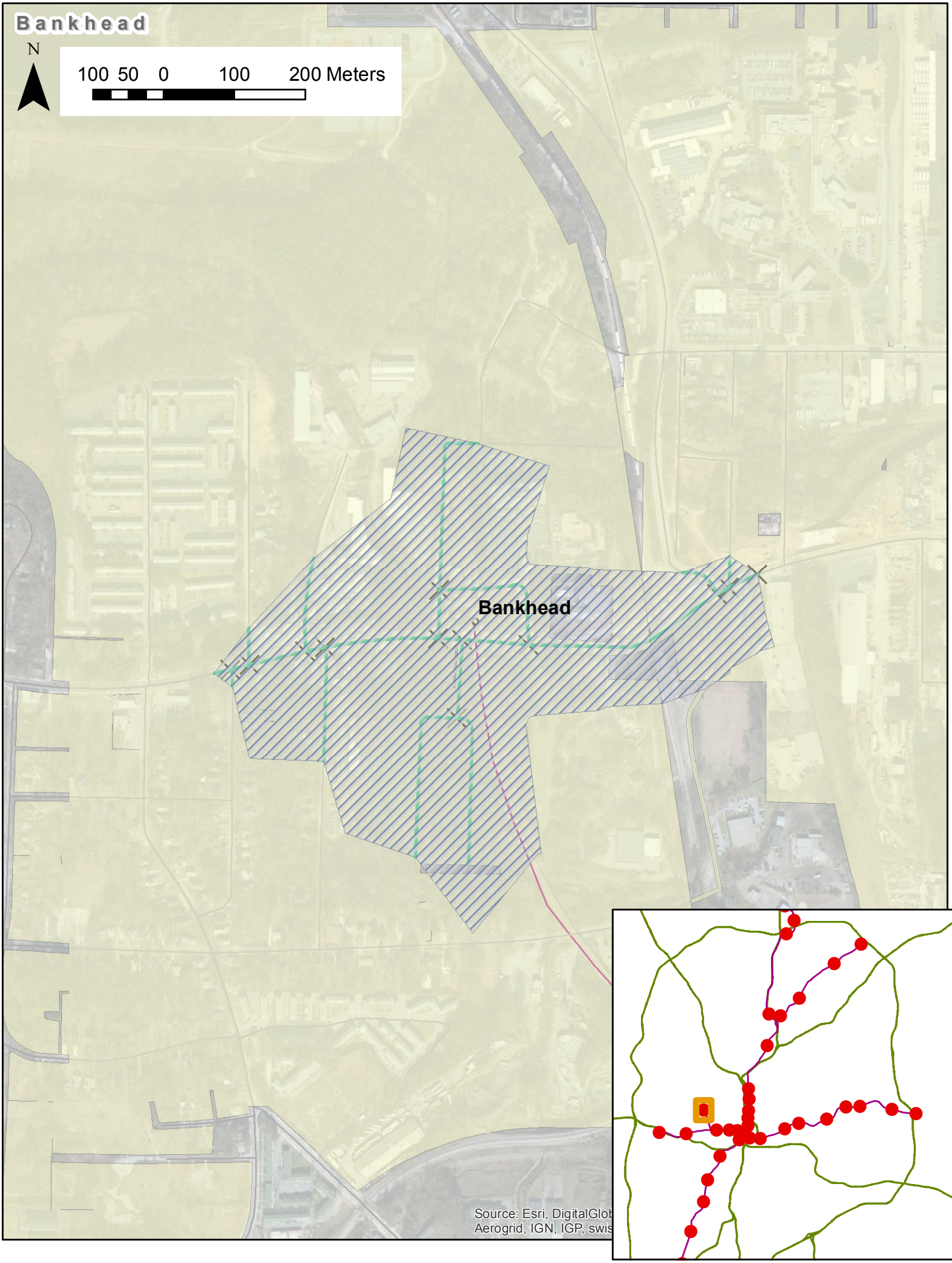

Van Dorn Street
N
100 50 0 100 200 Meters
Van Dorn Street
Source: Esri, DigitalGlobe
Aerogrid, IGN, IGP, swiss

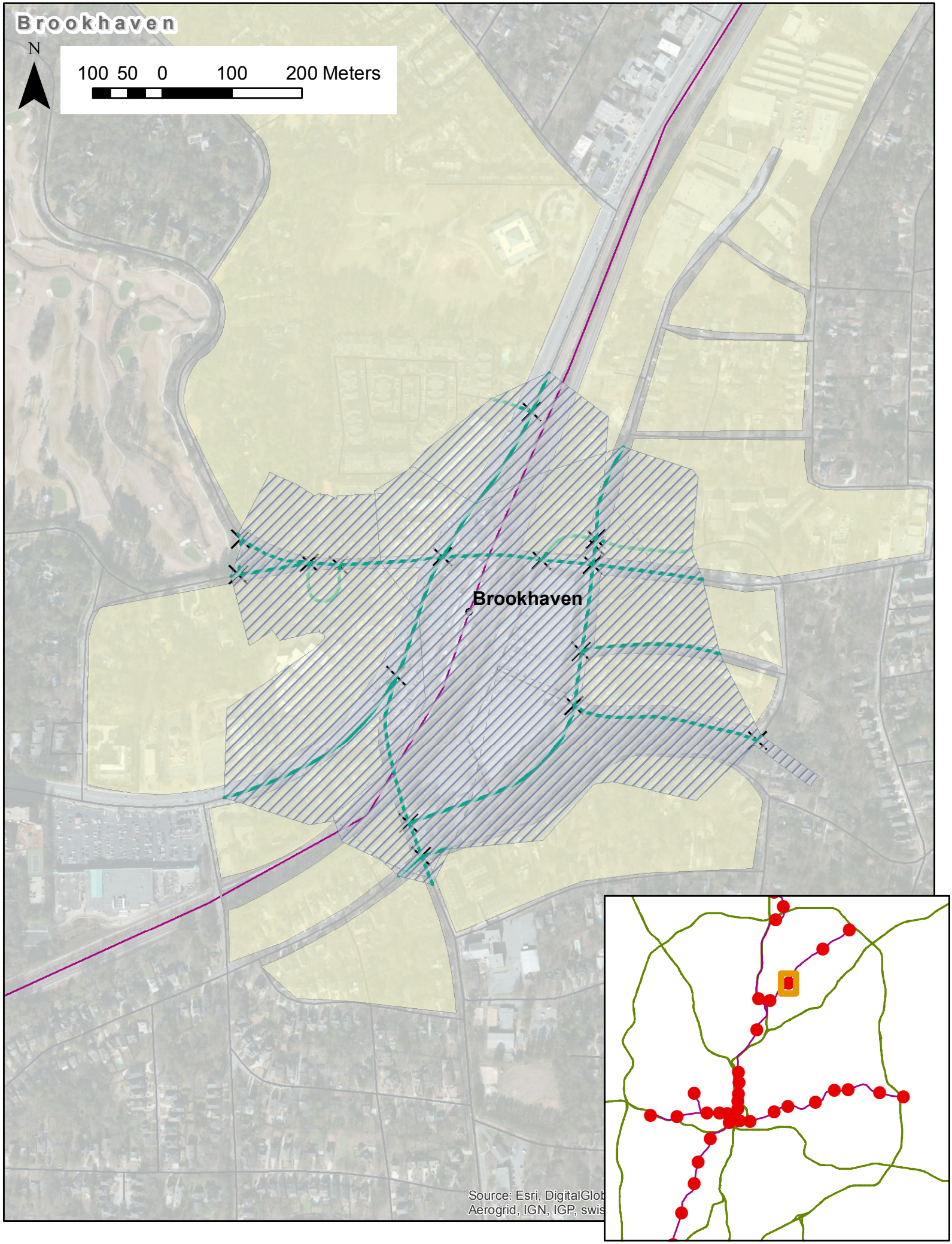

Airport
N
100 50 0 100 200 Meters
Airport
Source: Esri, DigitalGlob
Aerogrid, IGN, IGP, swis

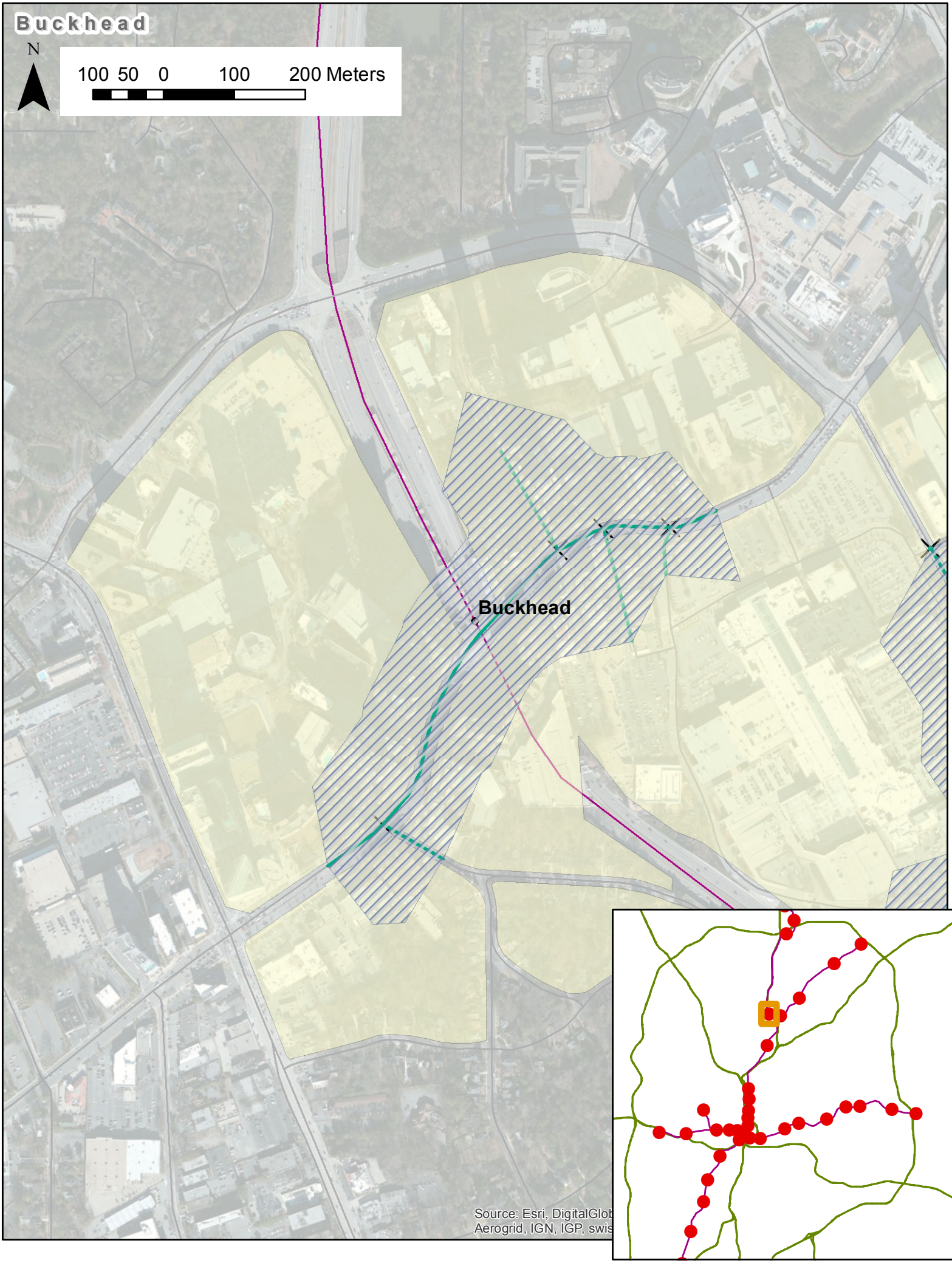

Arts Center
N
100 50 0 100 200 Meters
Arts Center
Source: Esri, DigitalGlob
Aerogrid, IGN, IGP, swis

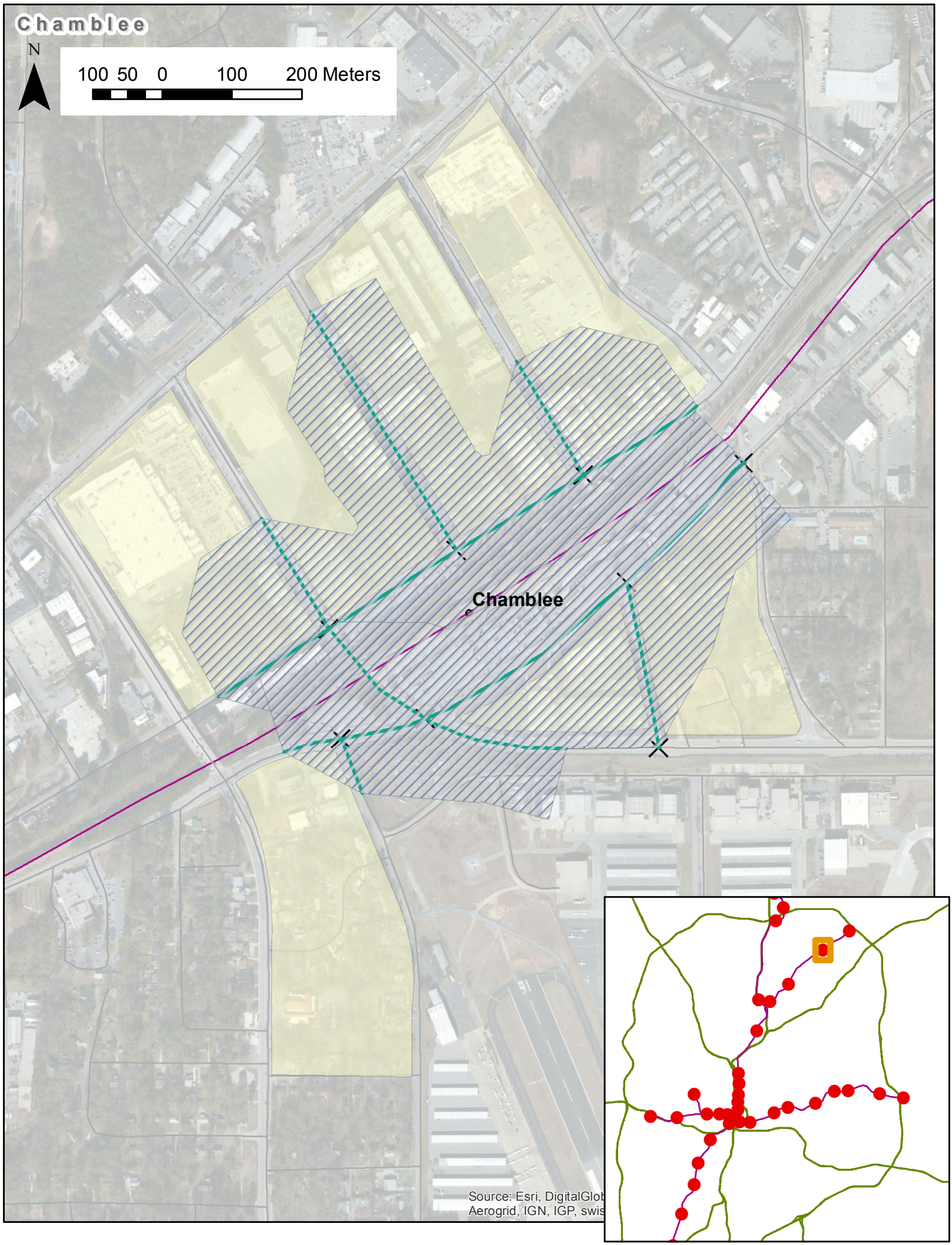

Ashby
N
100 50 0 100 200 Meters
Ashby
Source: Esri, DigitalGlob
Aerogrid, IGN, IGP, swis


Avondale
N
100 50 0 100 200 Meters
Avondale
Source: Esri, DigitalGlob
Aerogrid, IGN, IGP, swis


Bankhead
N
100 50 0 100 200 Meters
Bankhead
Source: Esri, DigitalGlob
Aerogrid, IGN, IGP, swis


Brookhaven
N
100 50 0 100 200 Meters
Brookhaven
Source: Esri, DigitalGlob
Aerogrid, IGN, IGP, swis


Buckhead
N
100 50 0 100 200 Meters
Buckhead
Source: Esri, DigitalGlob
Aerogrid, IGN, IGP, swis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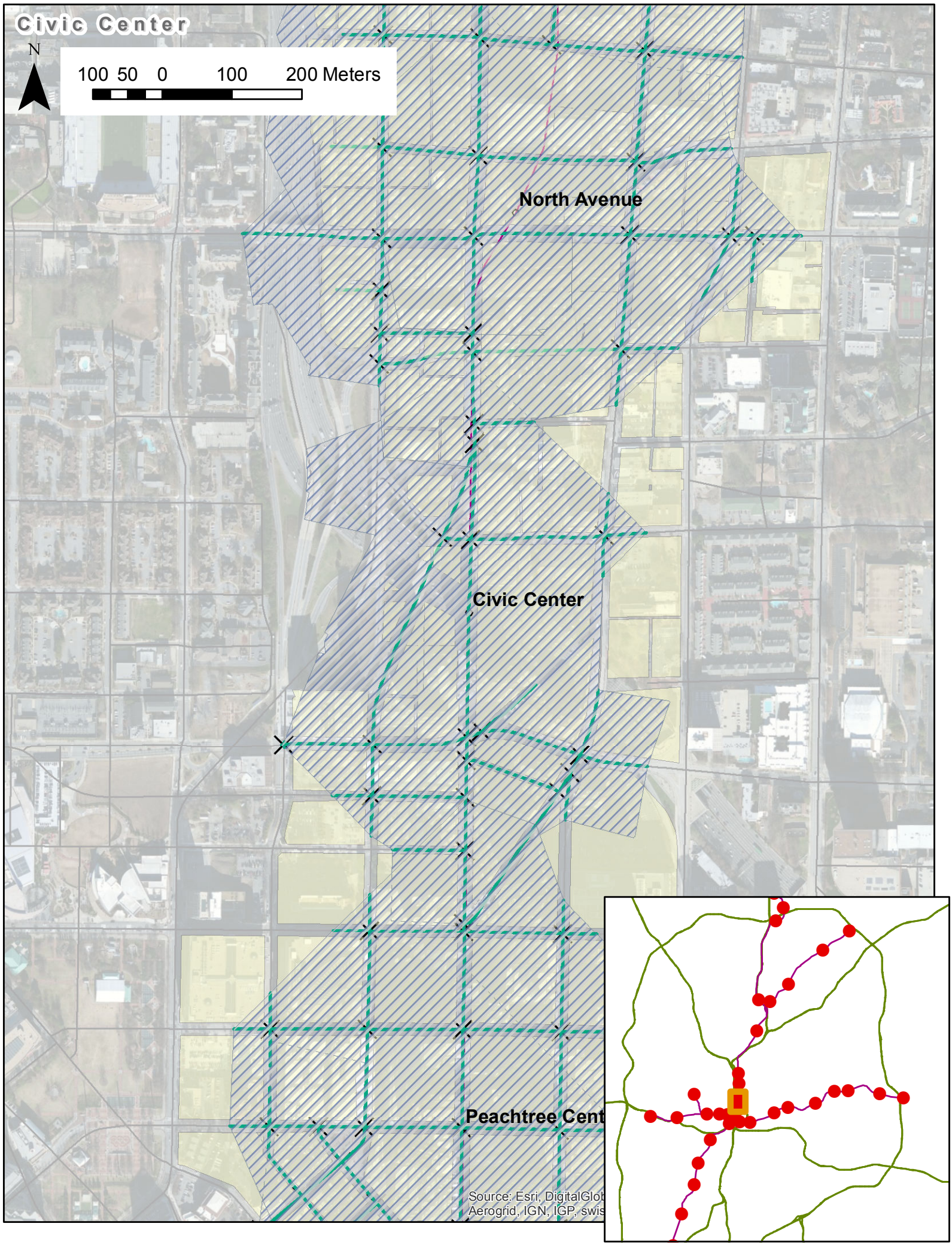
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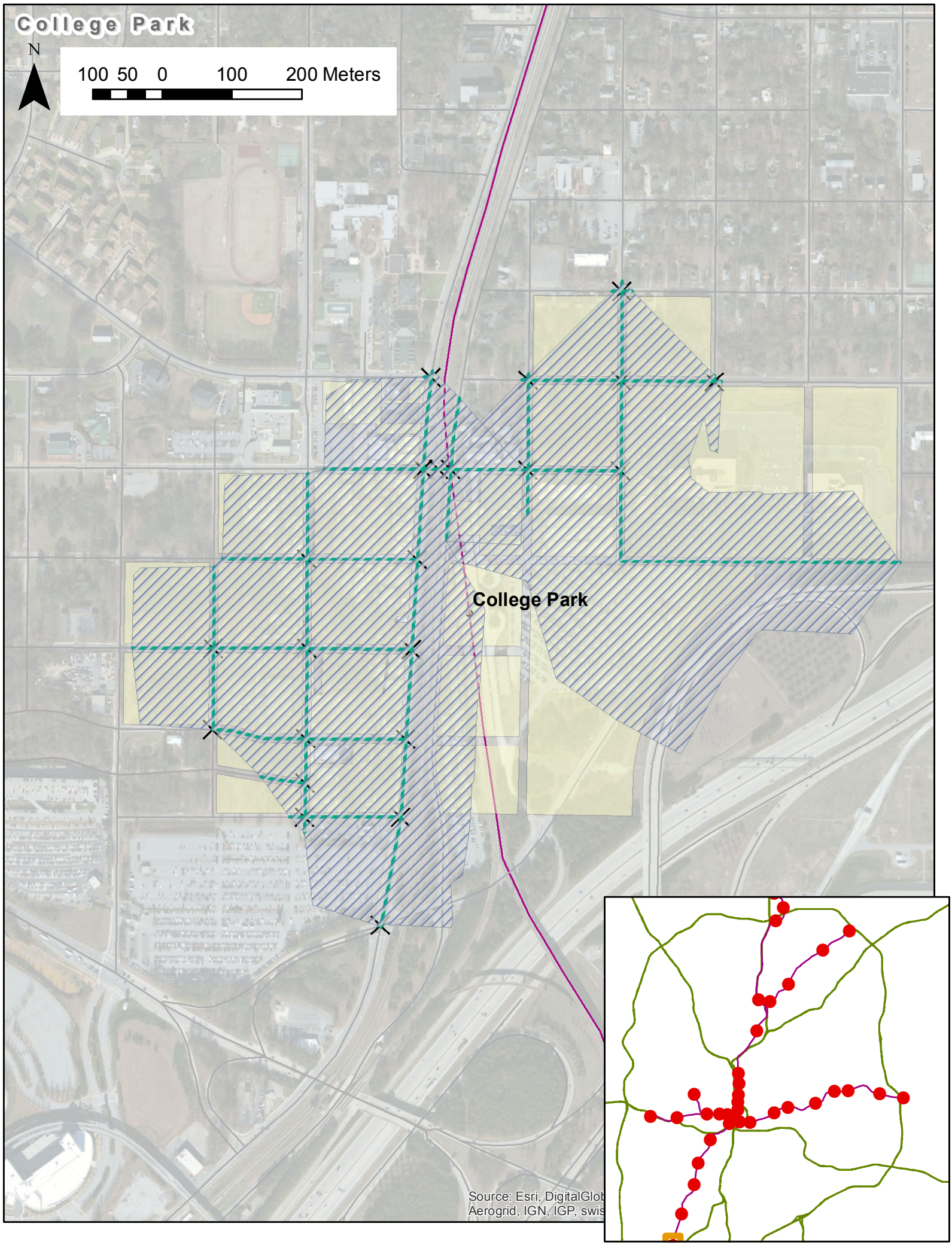
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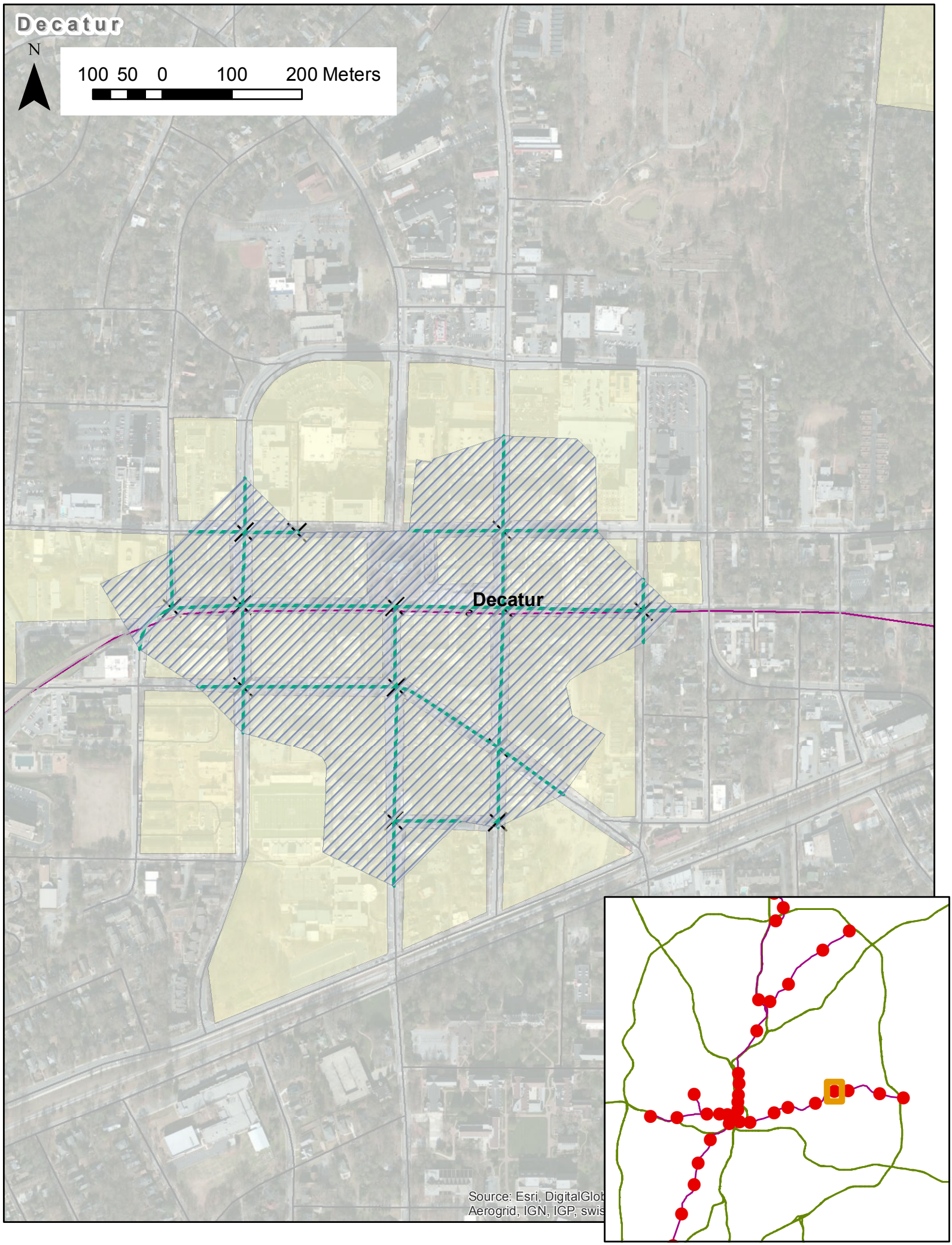
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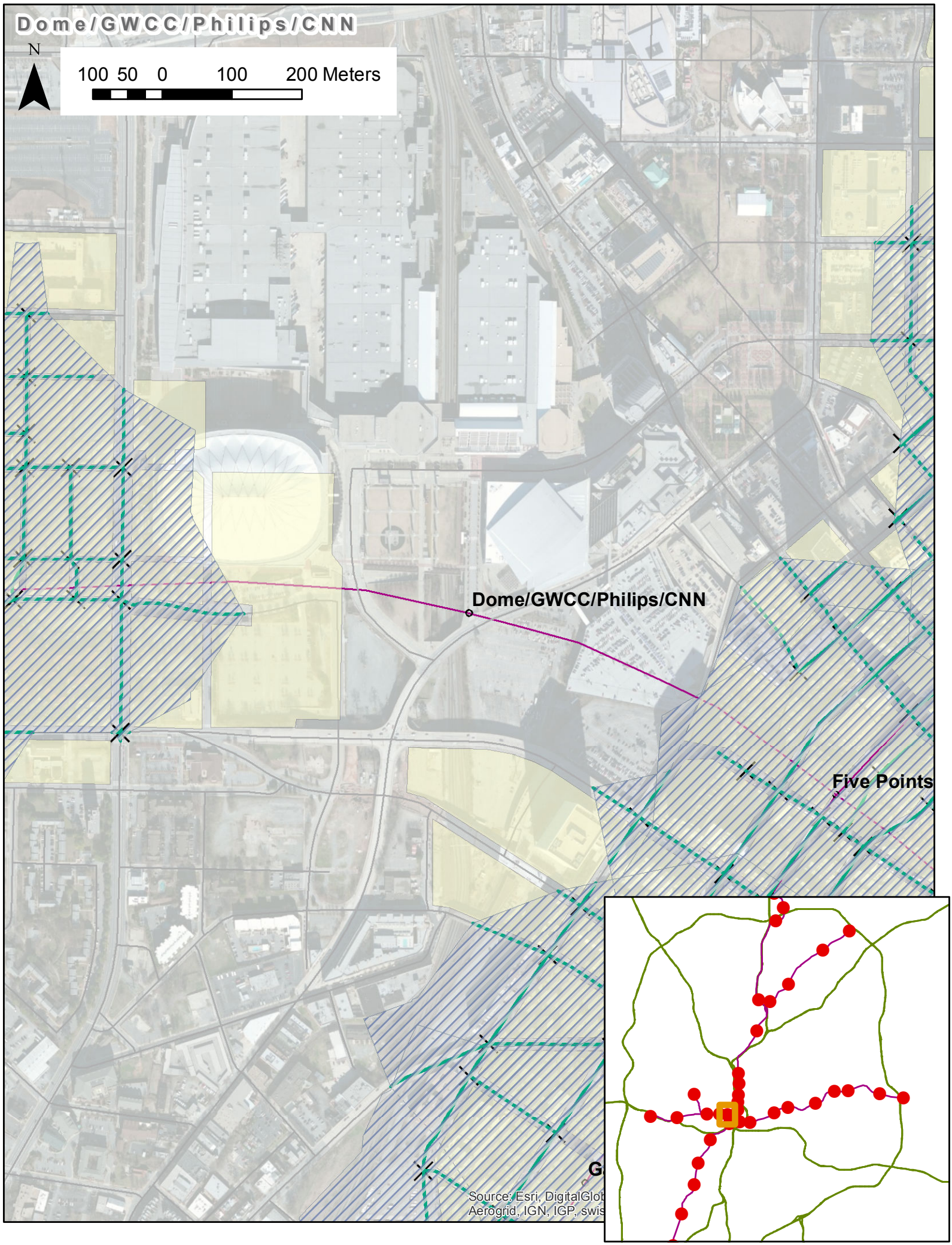
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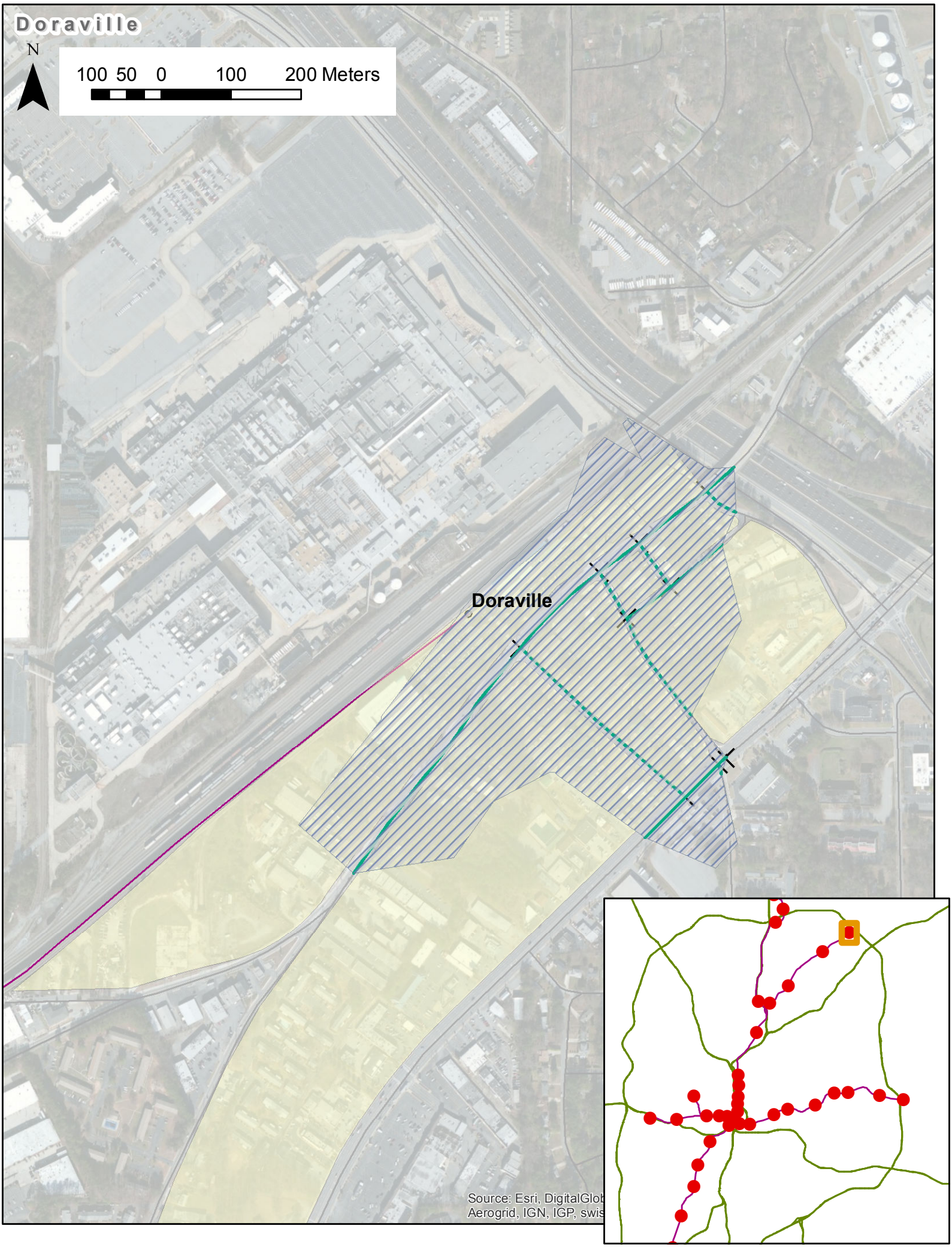
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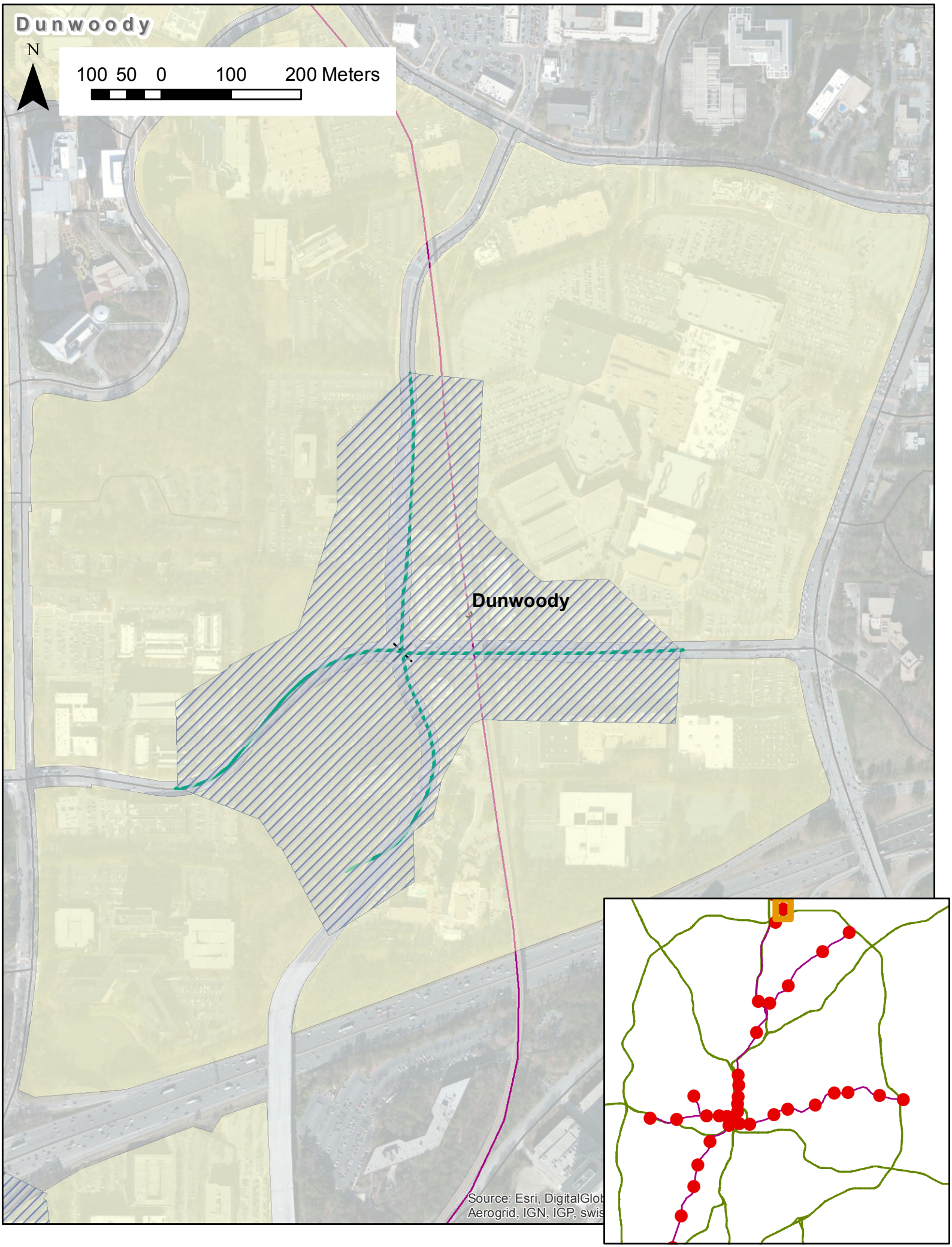
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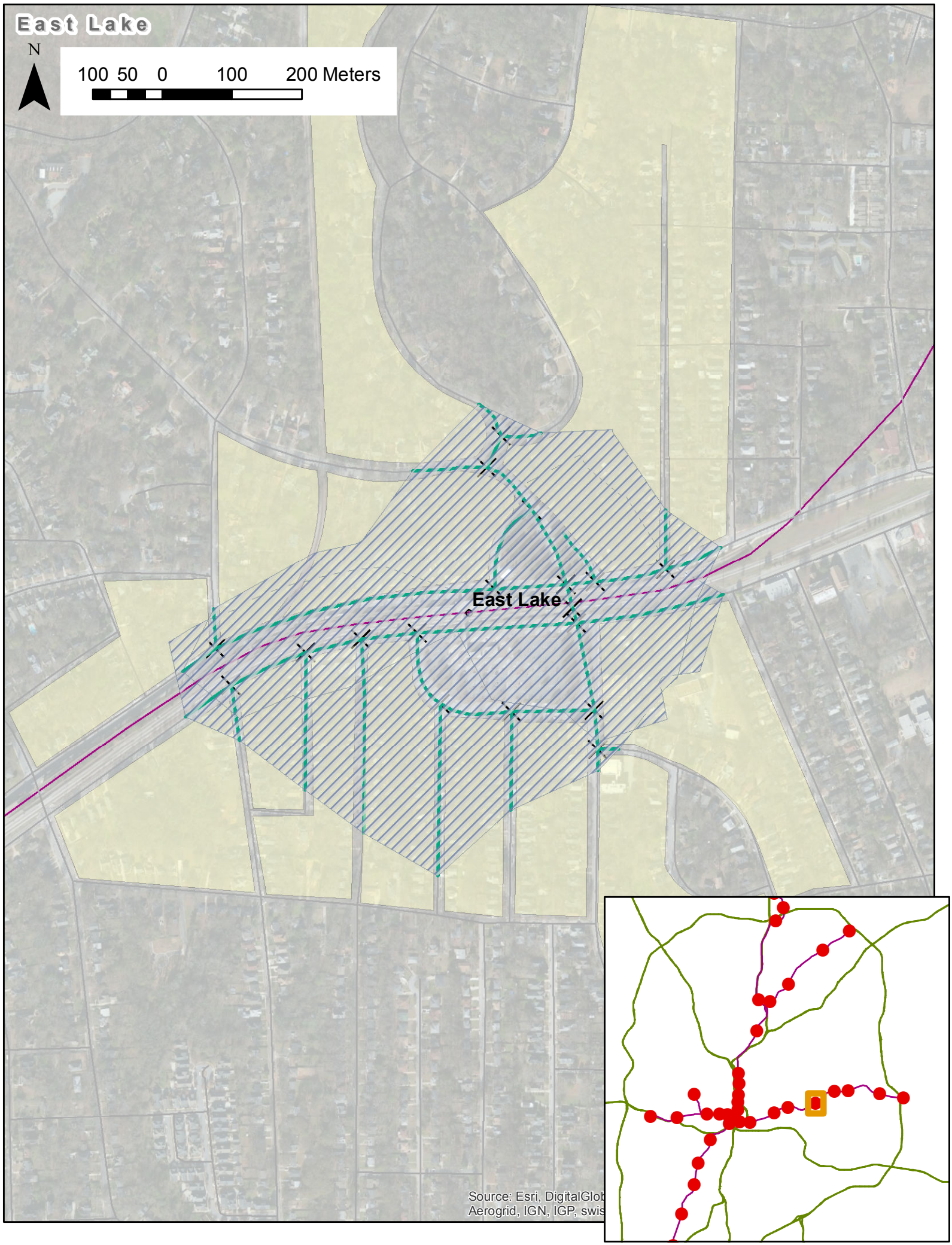
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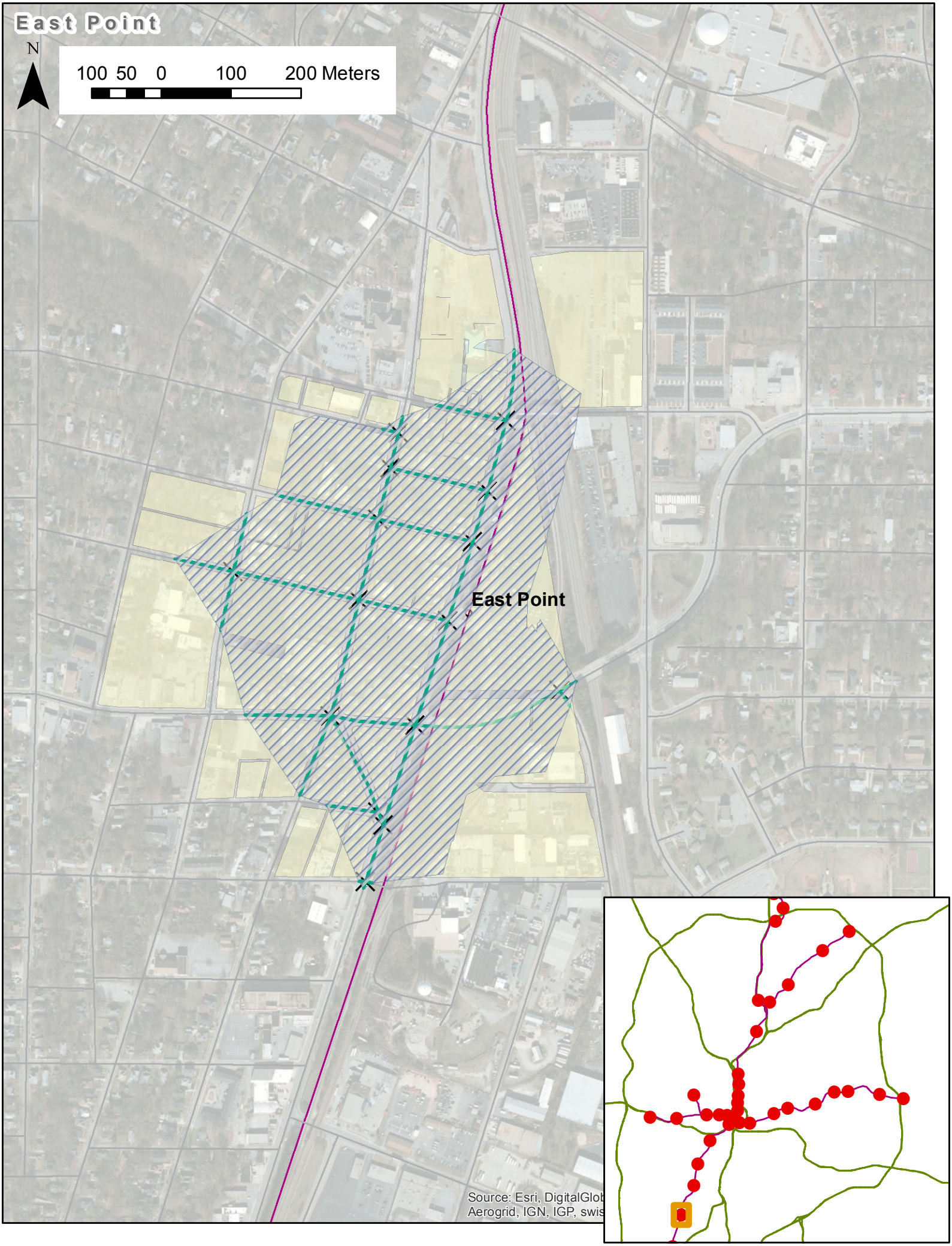
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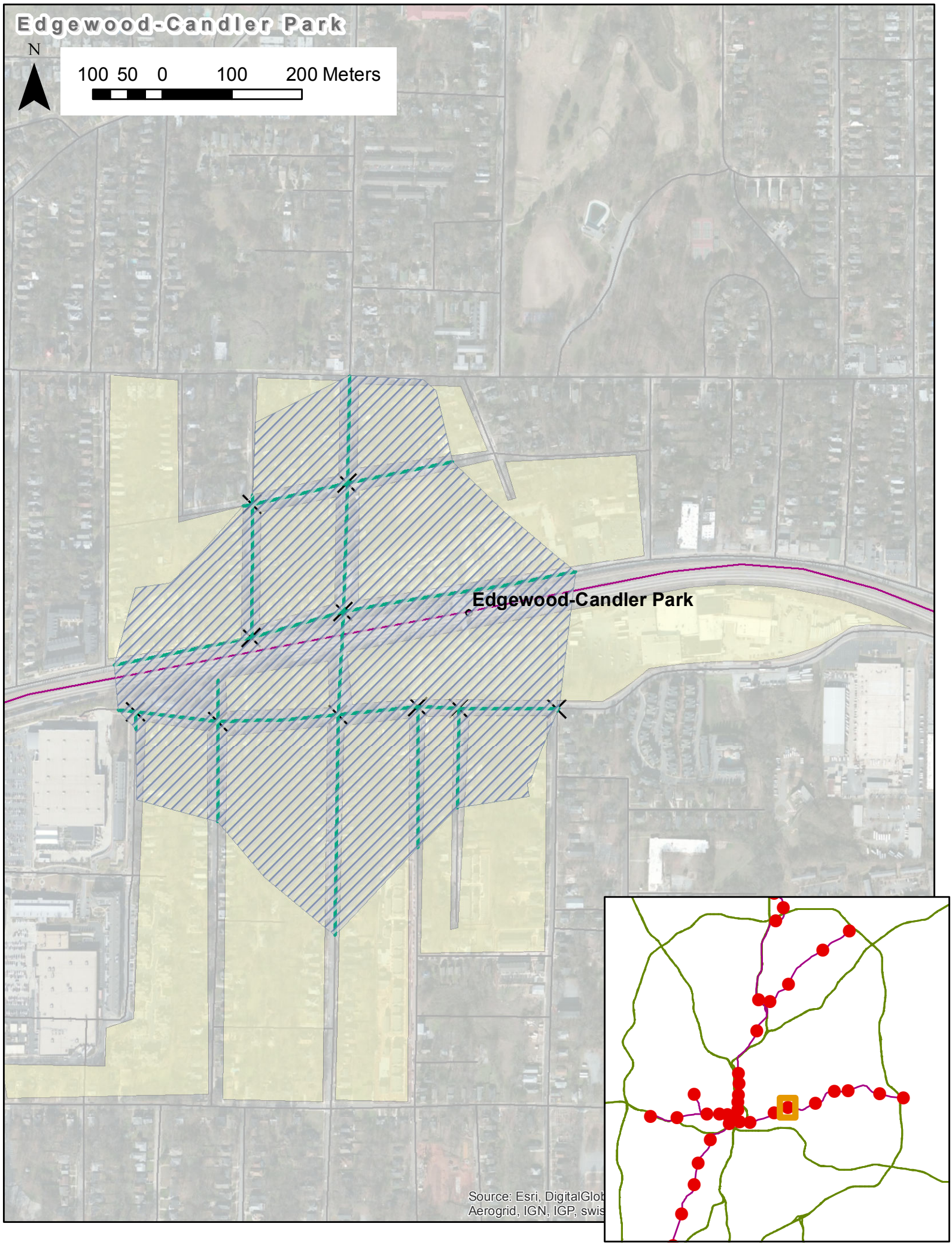
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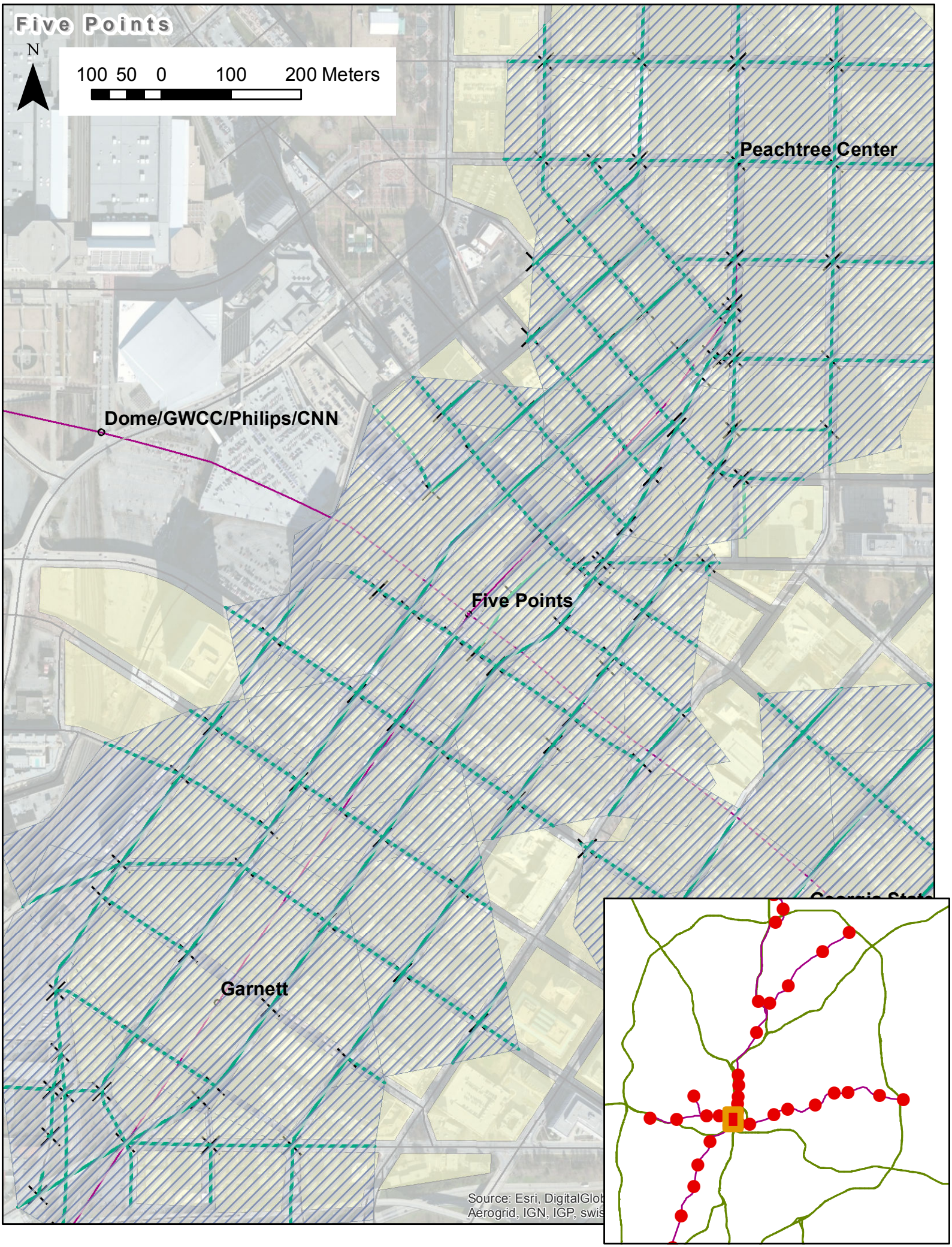
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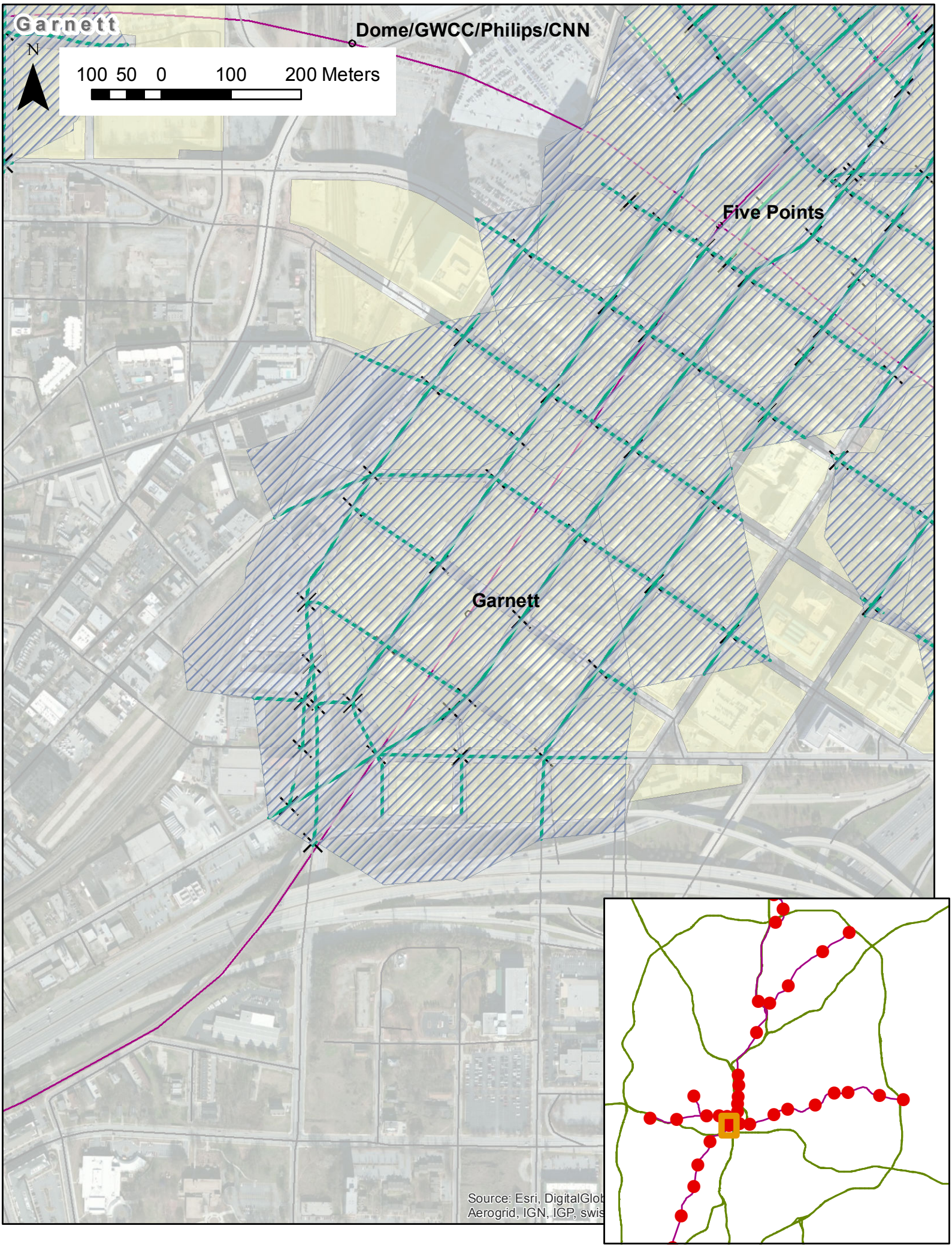
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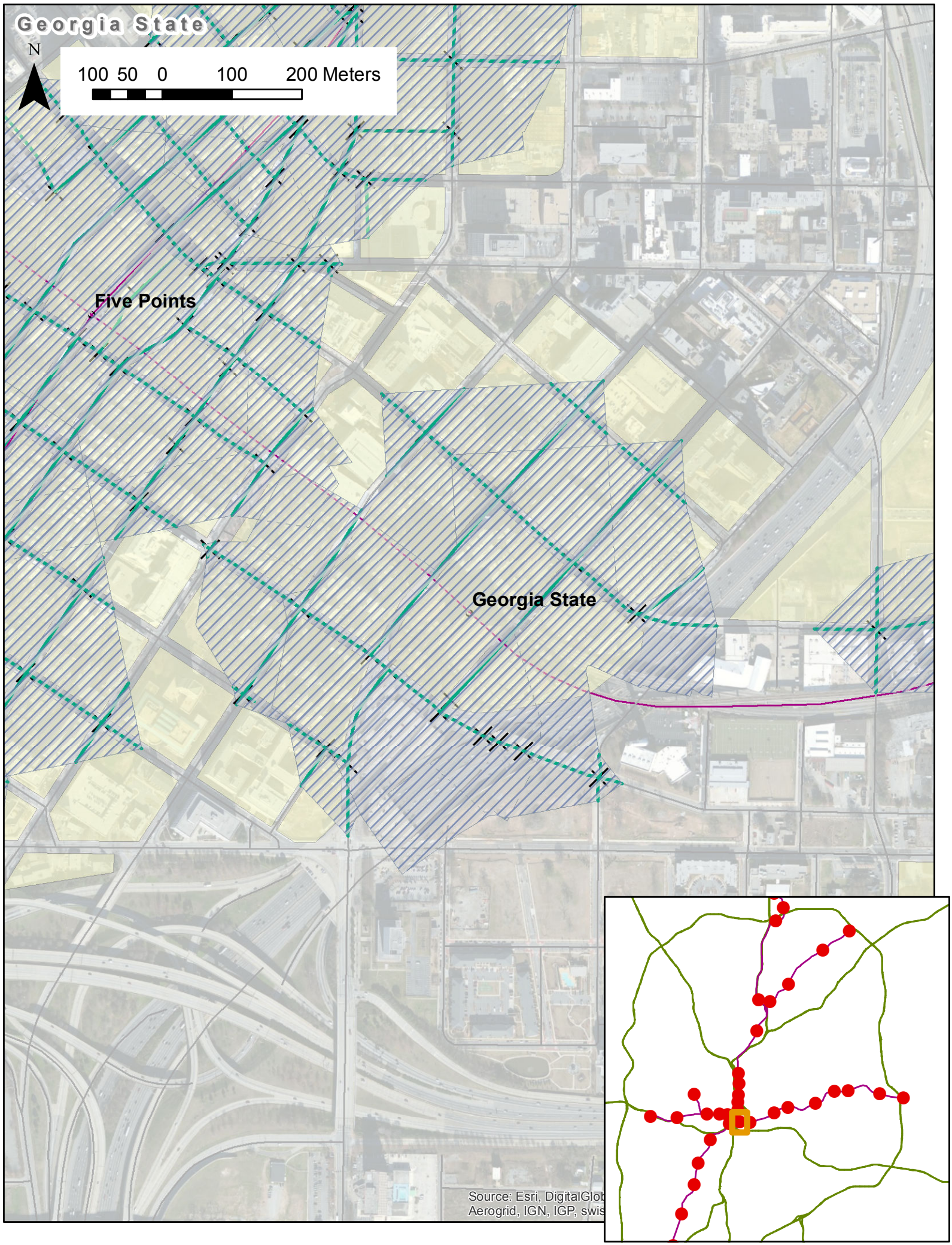
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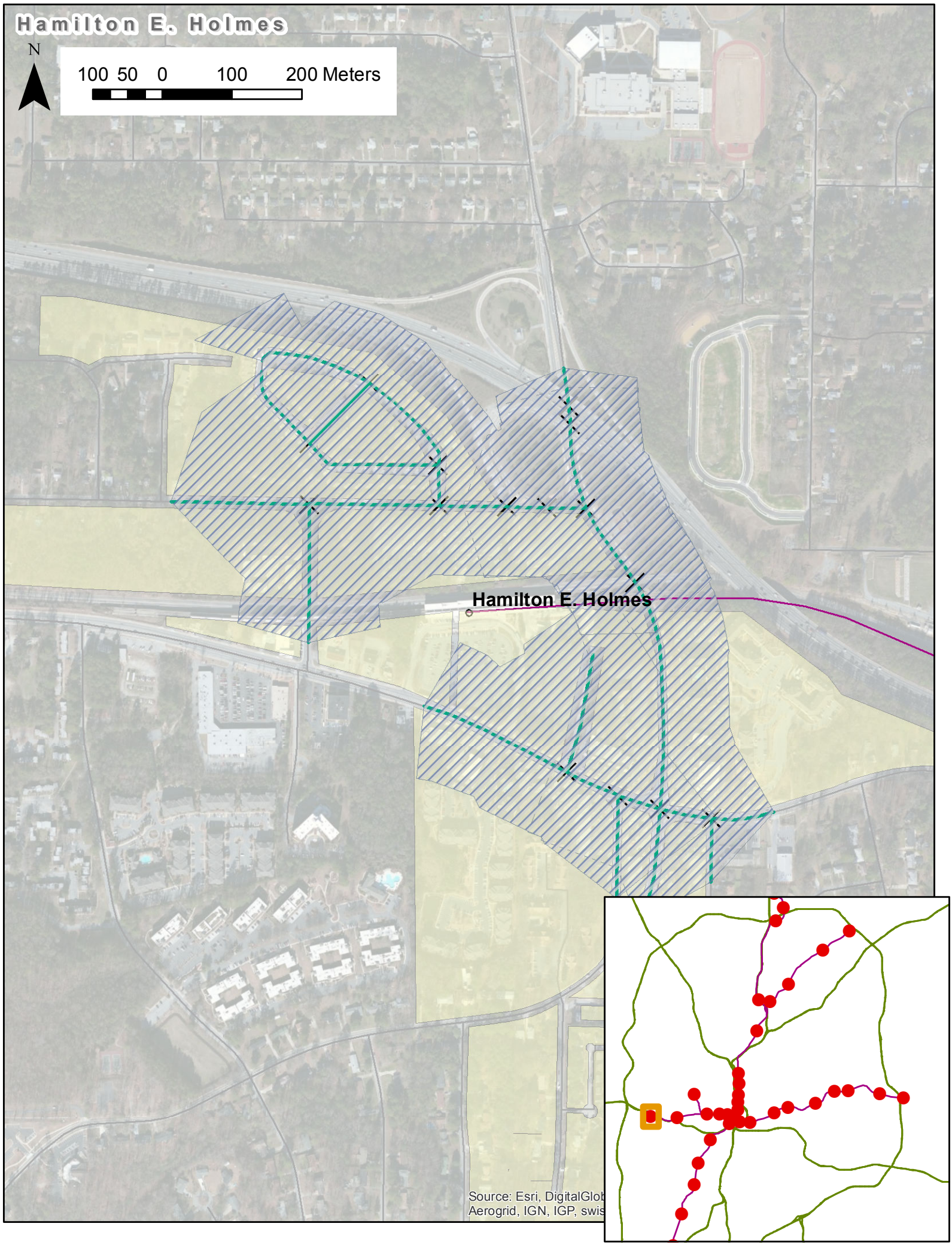
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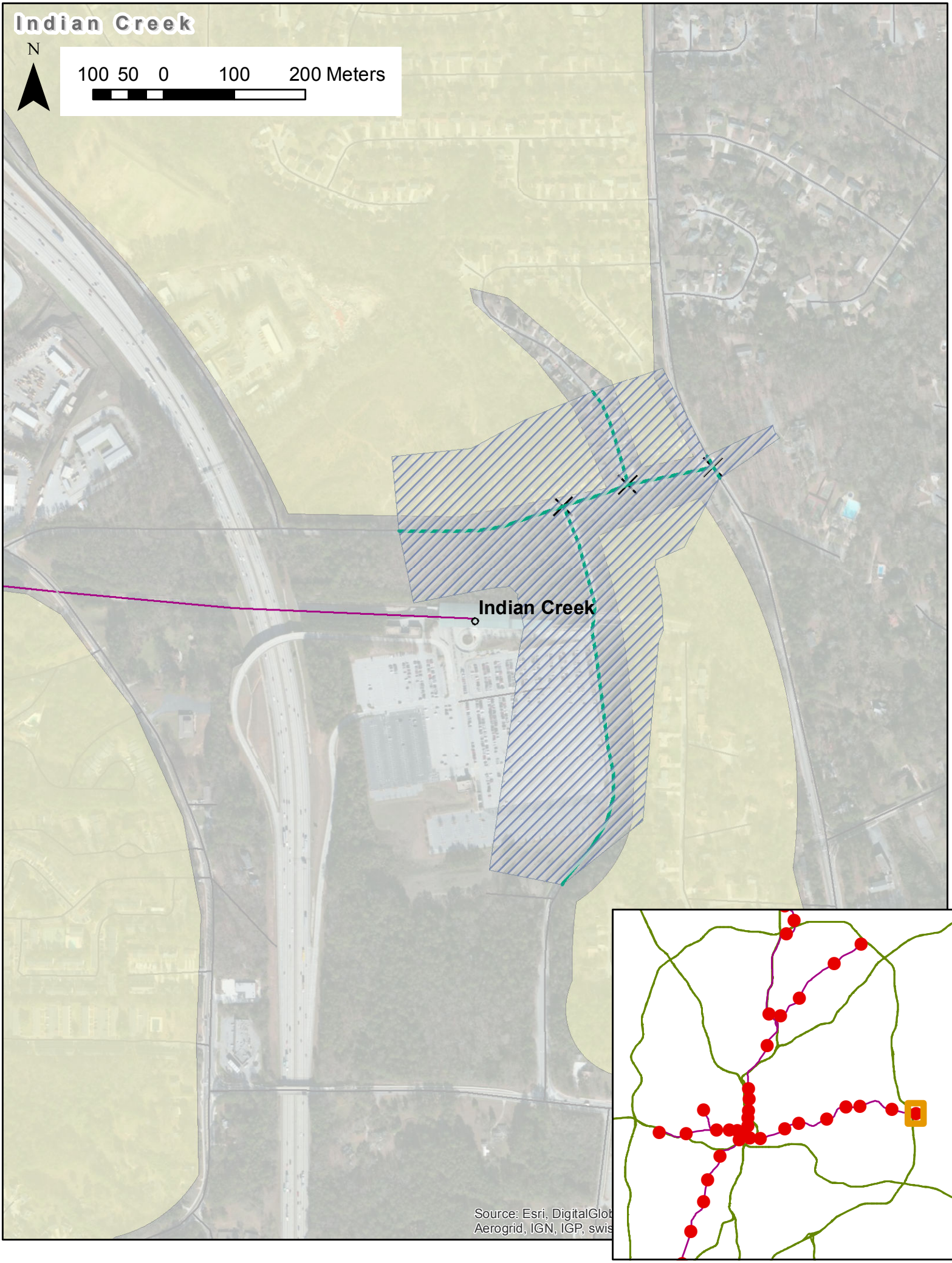
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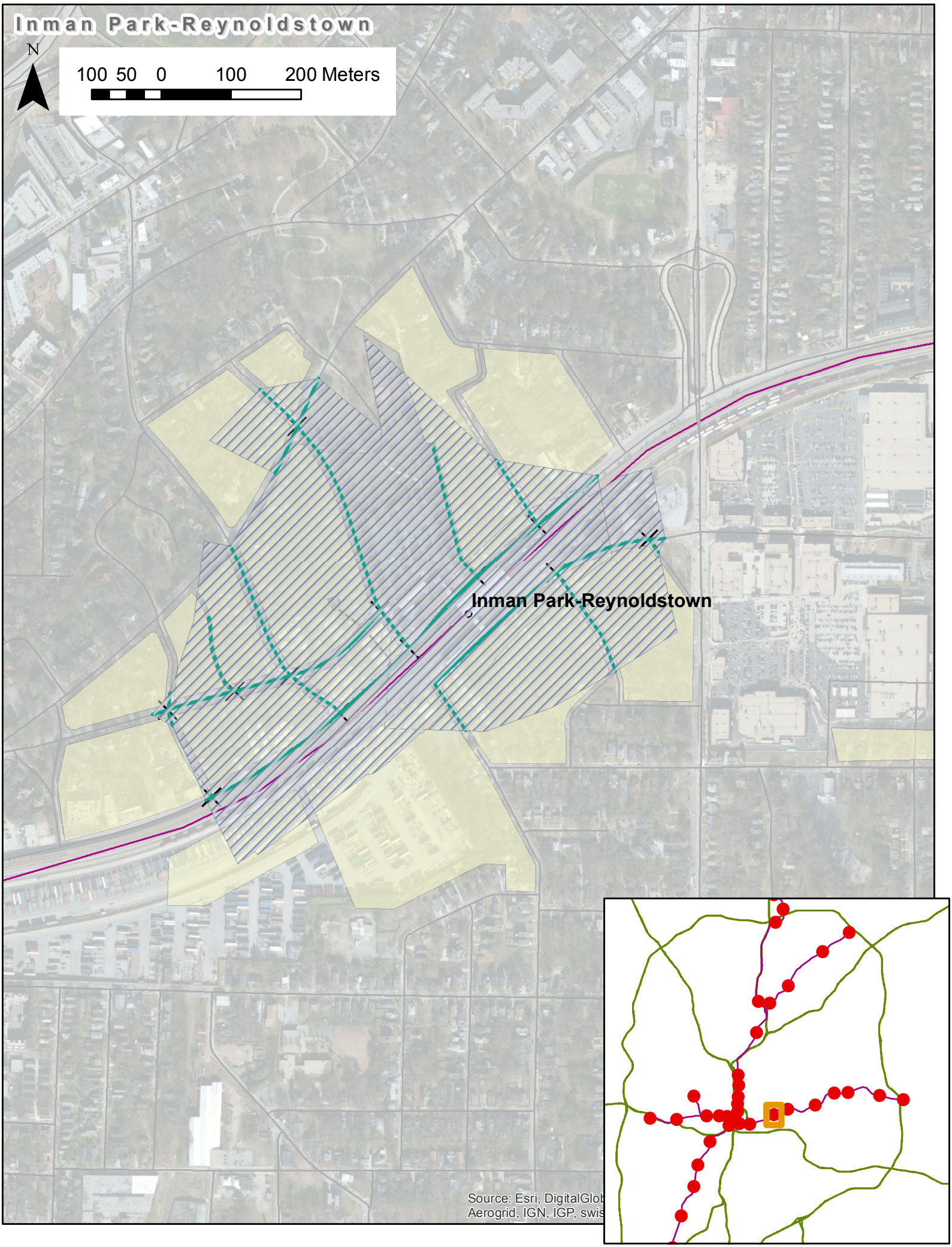
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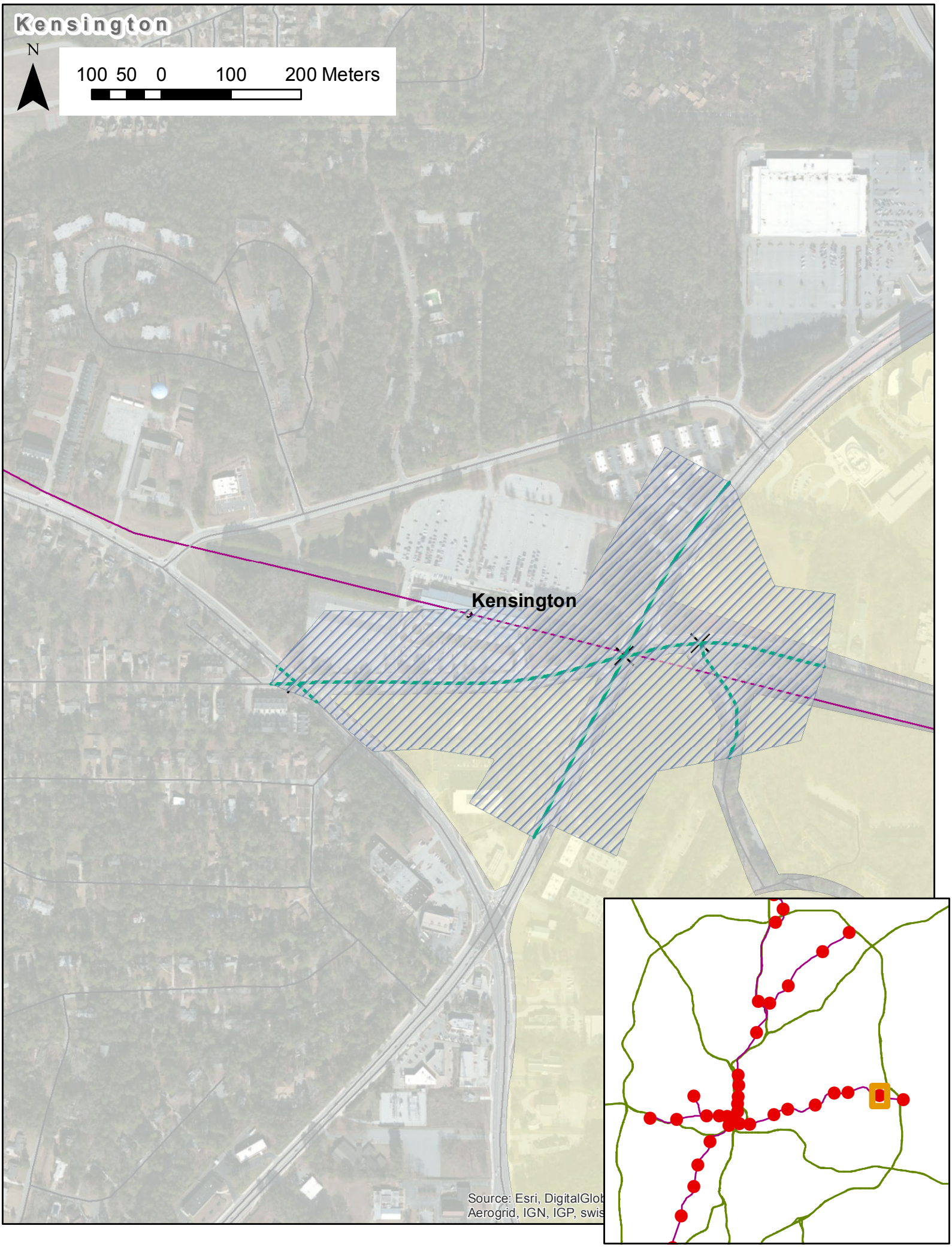
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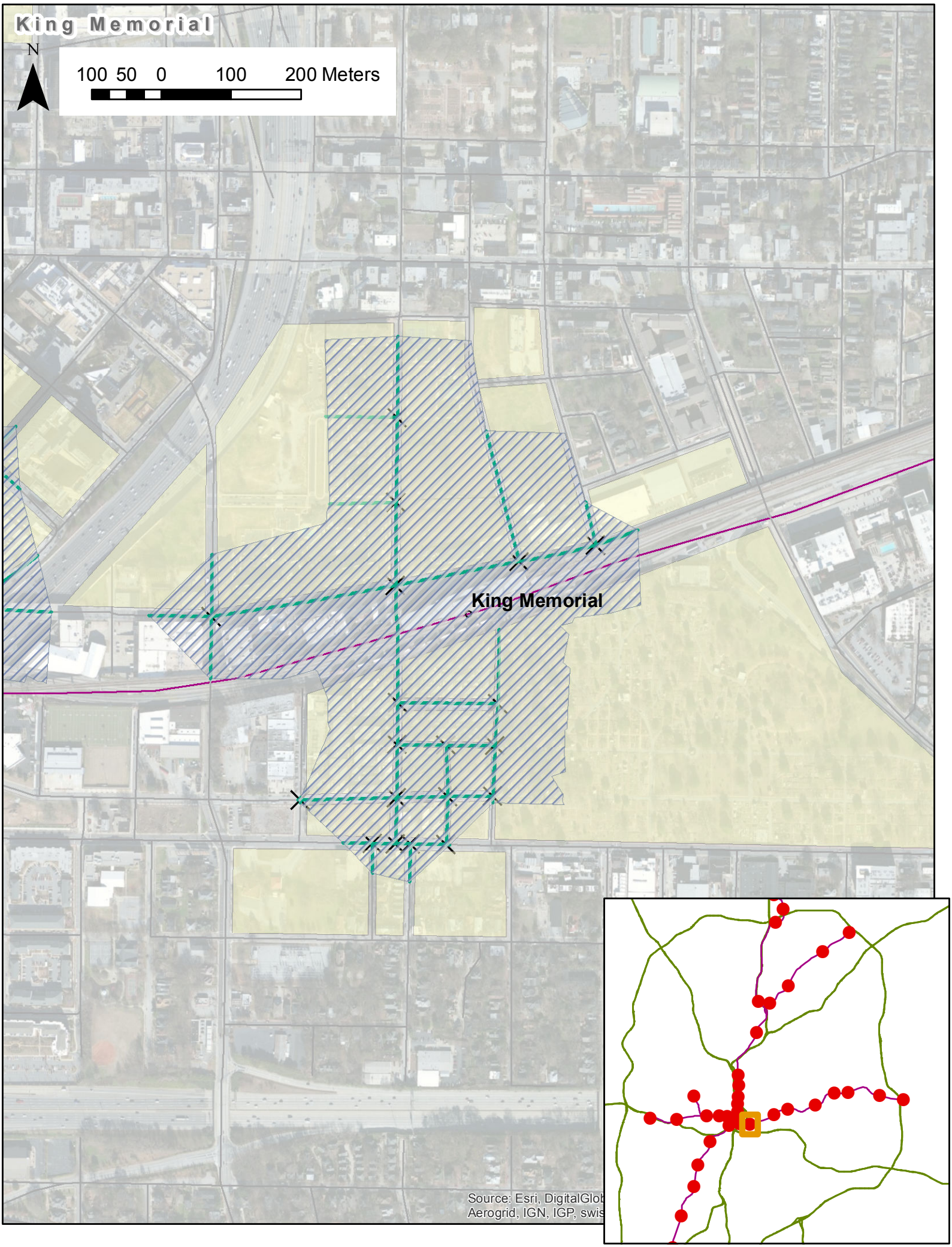
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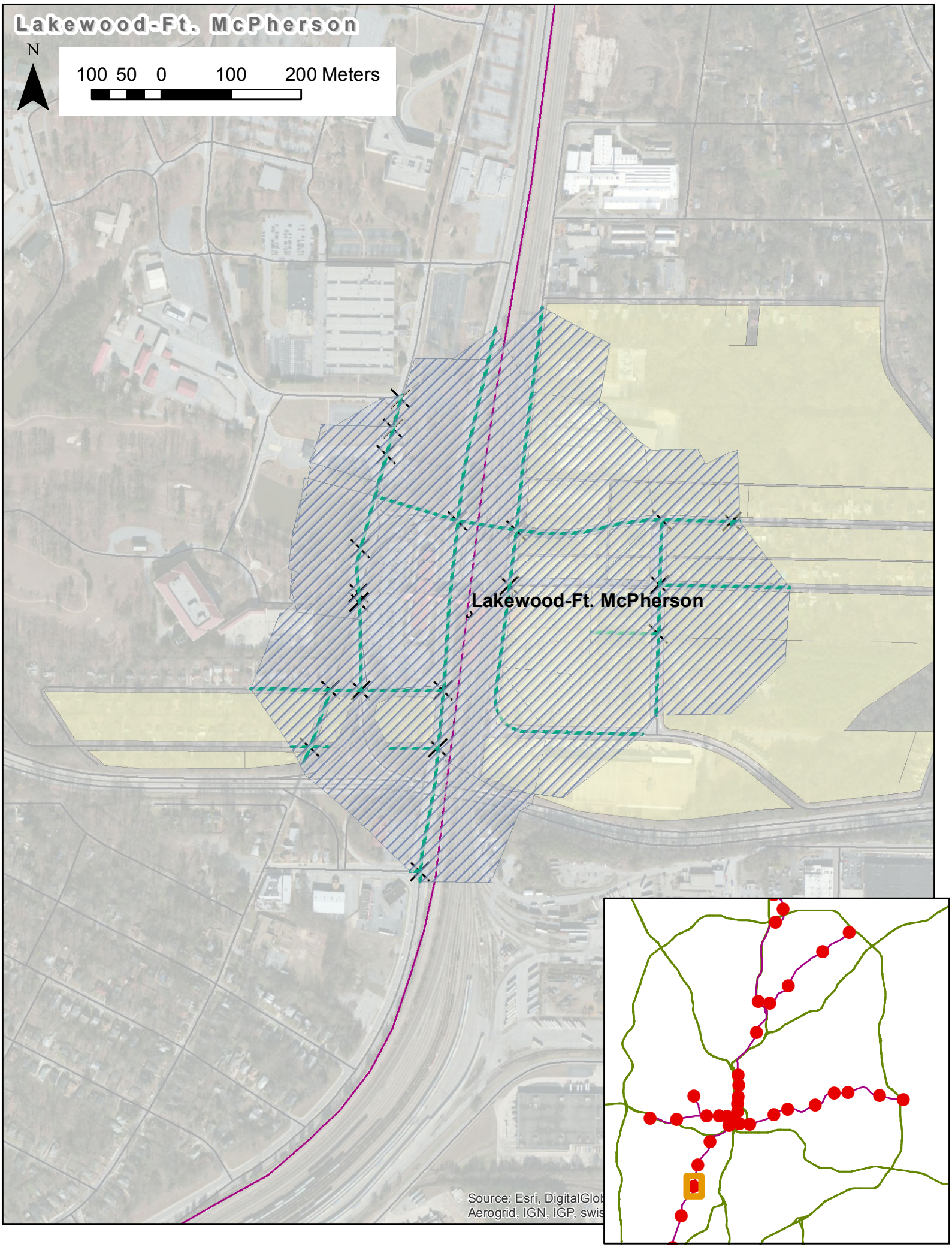
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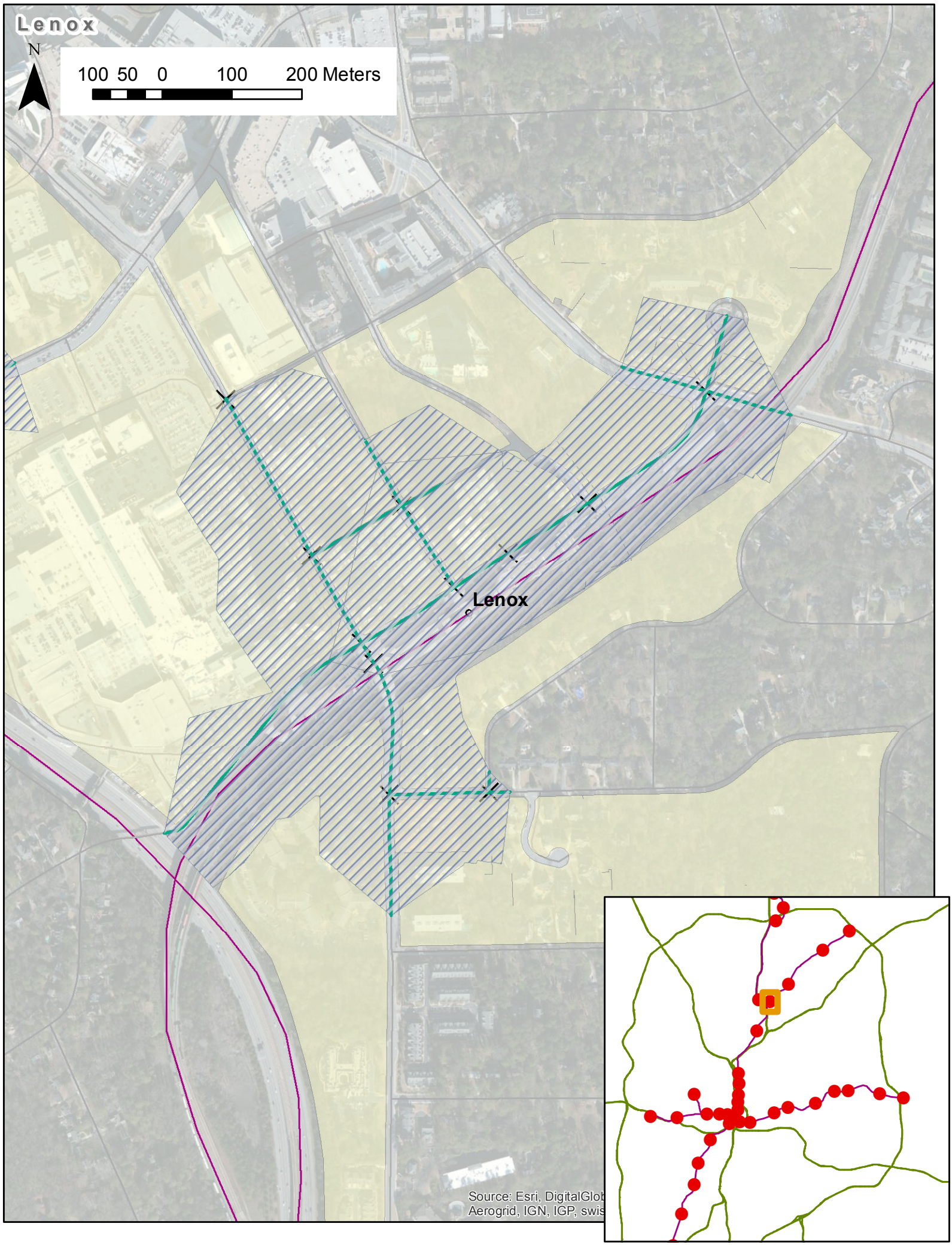
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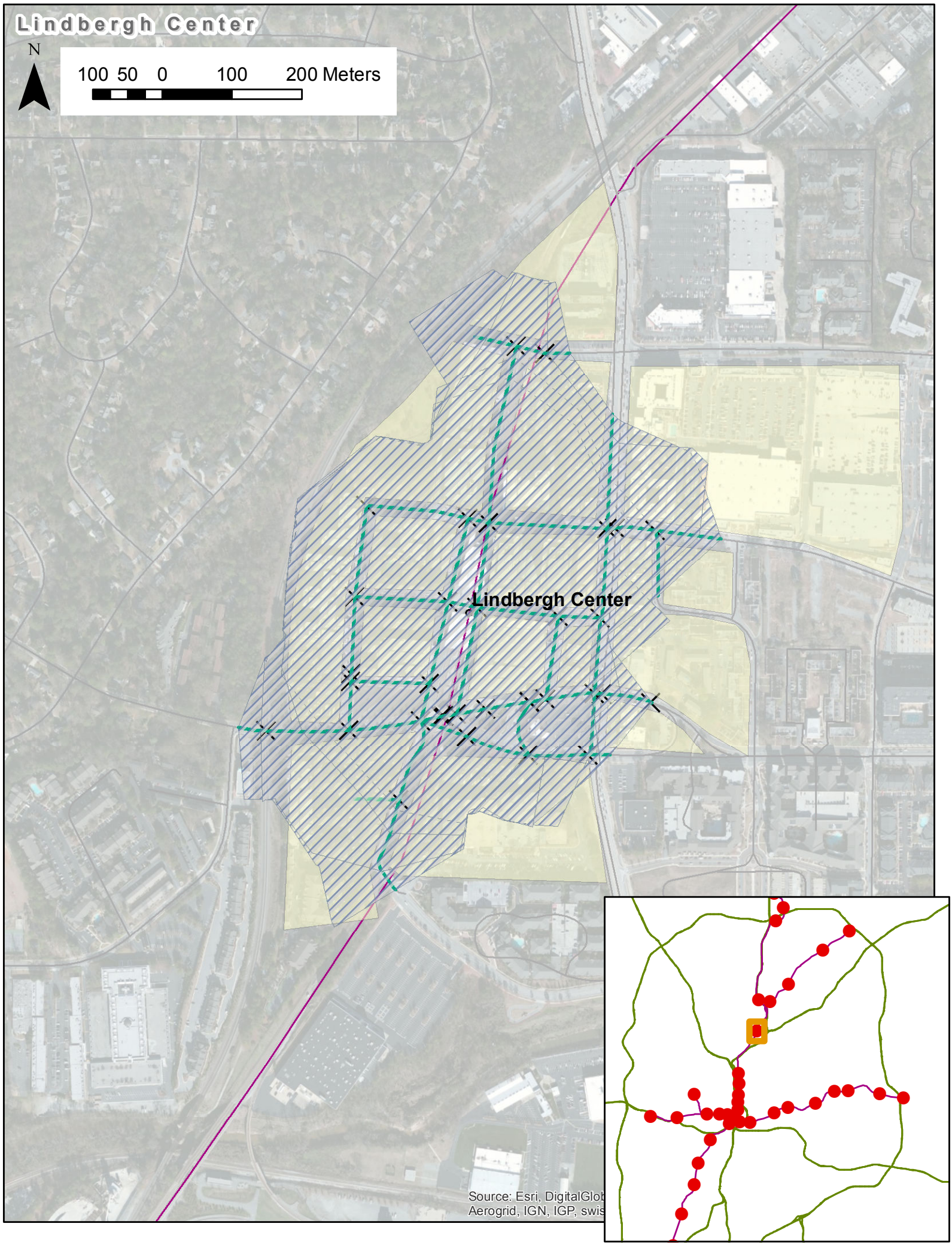
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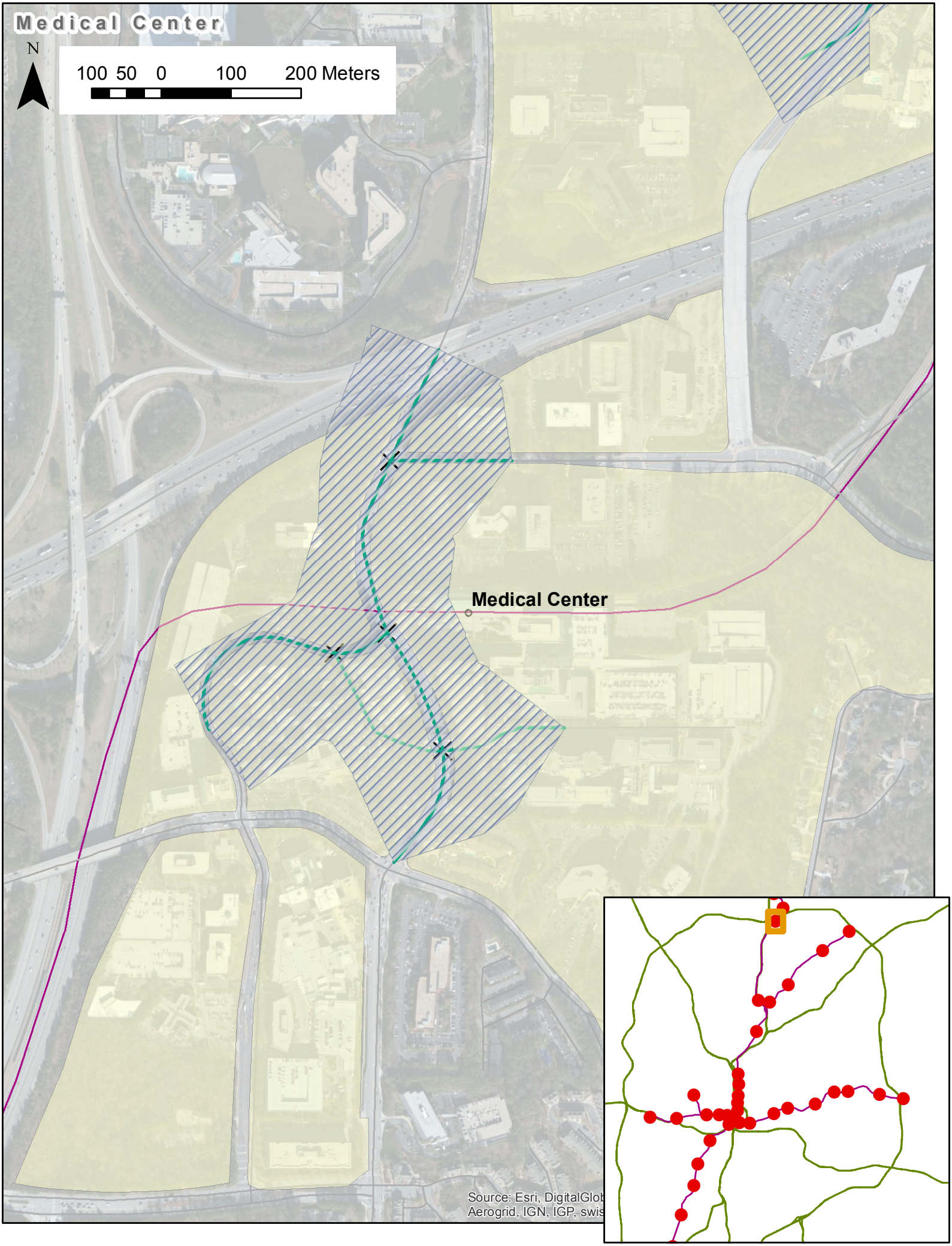
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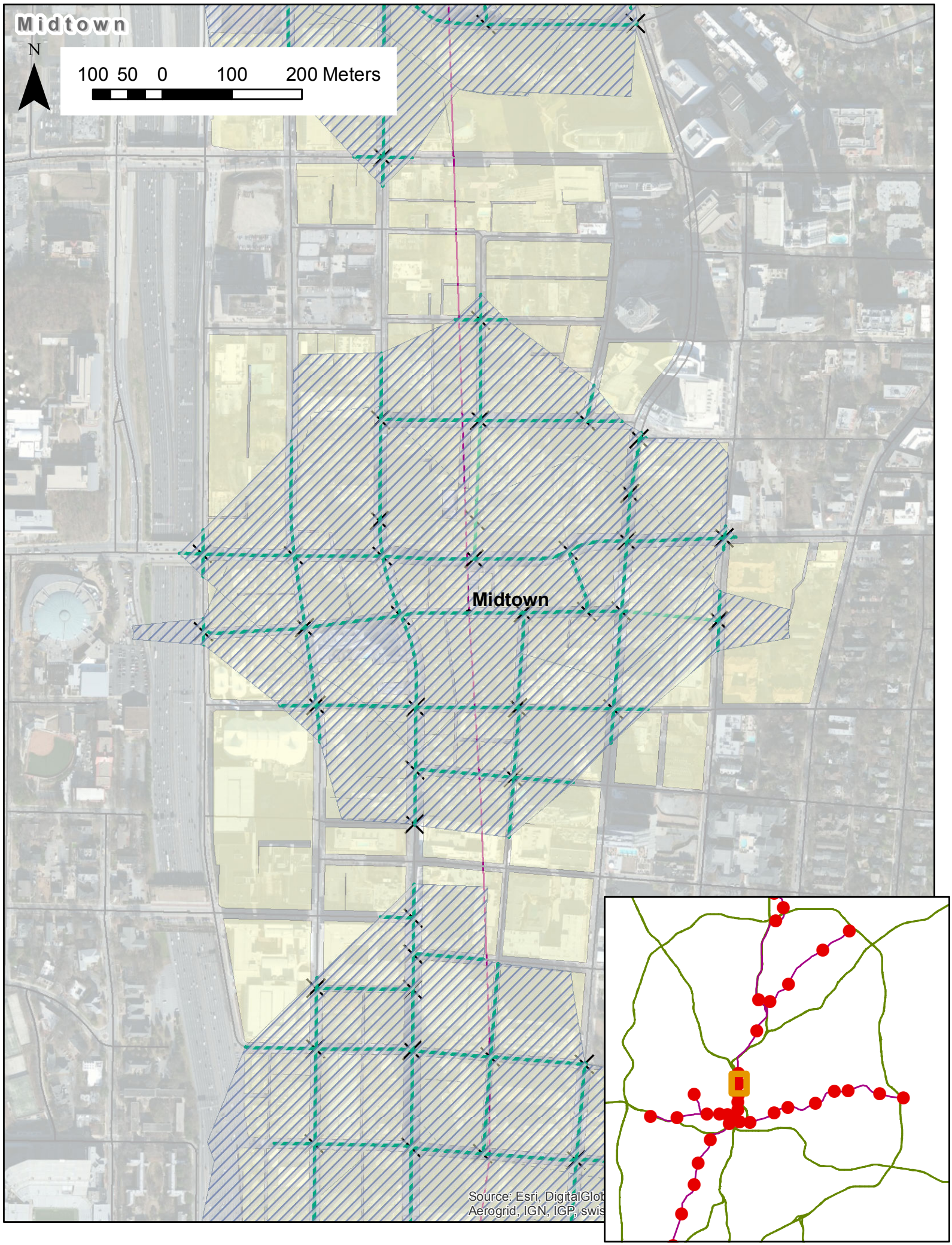
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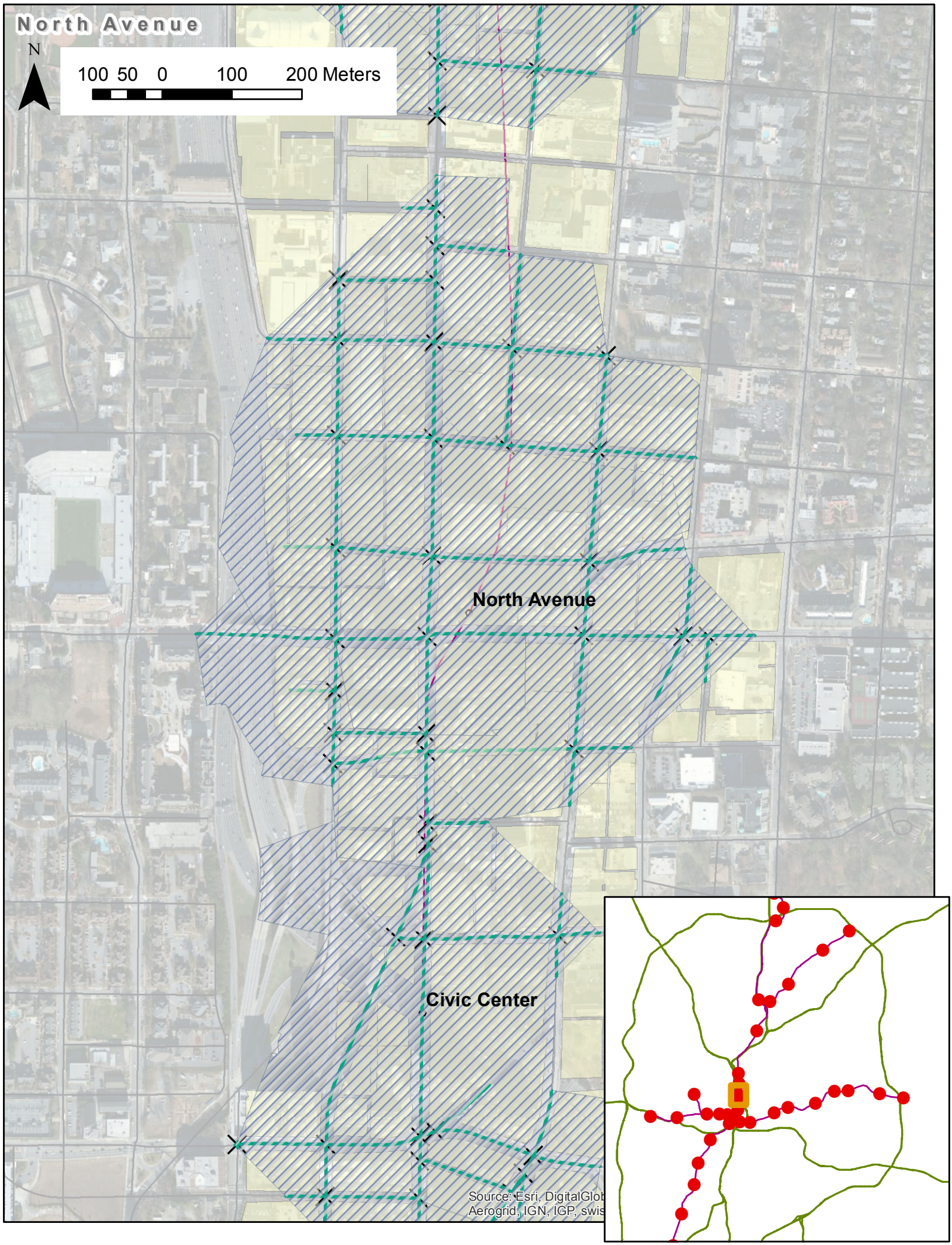
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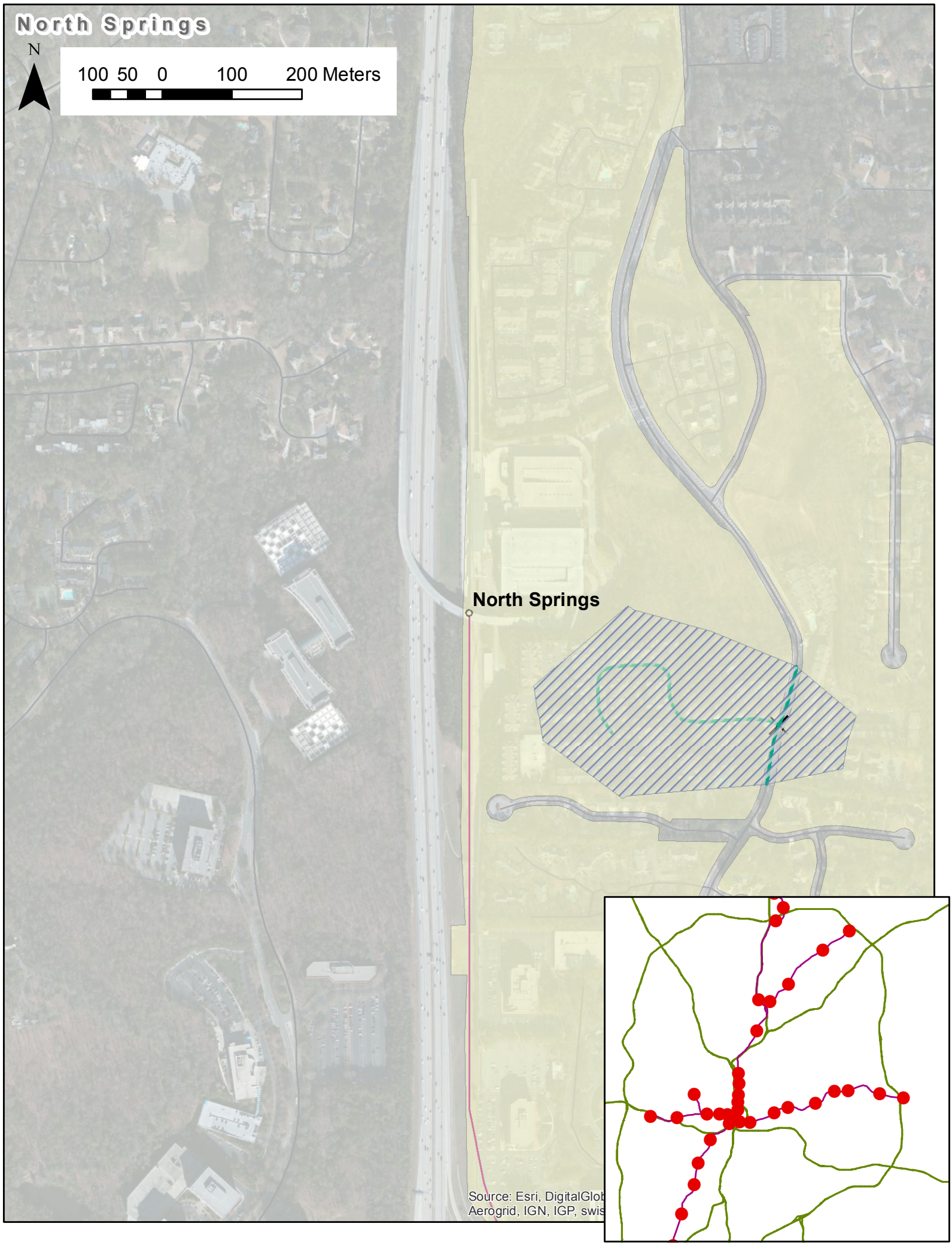
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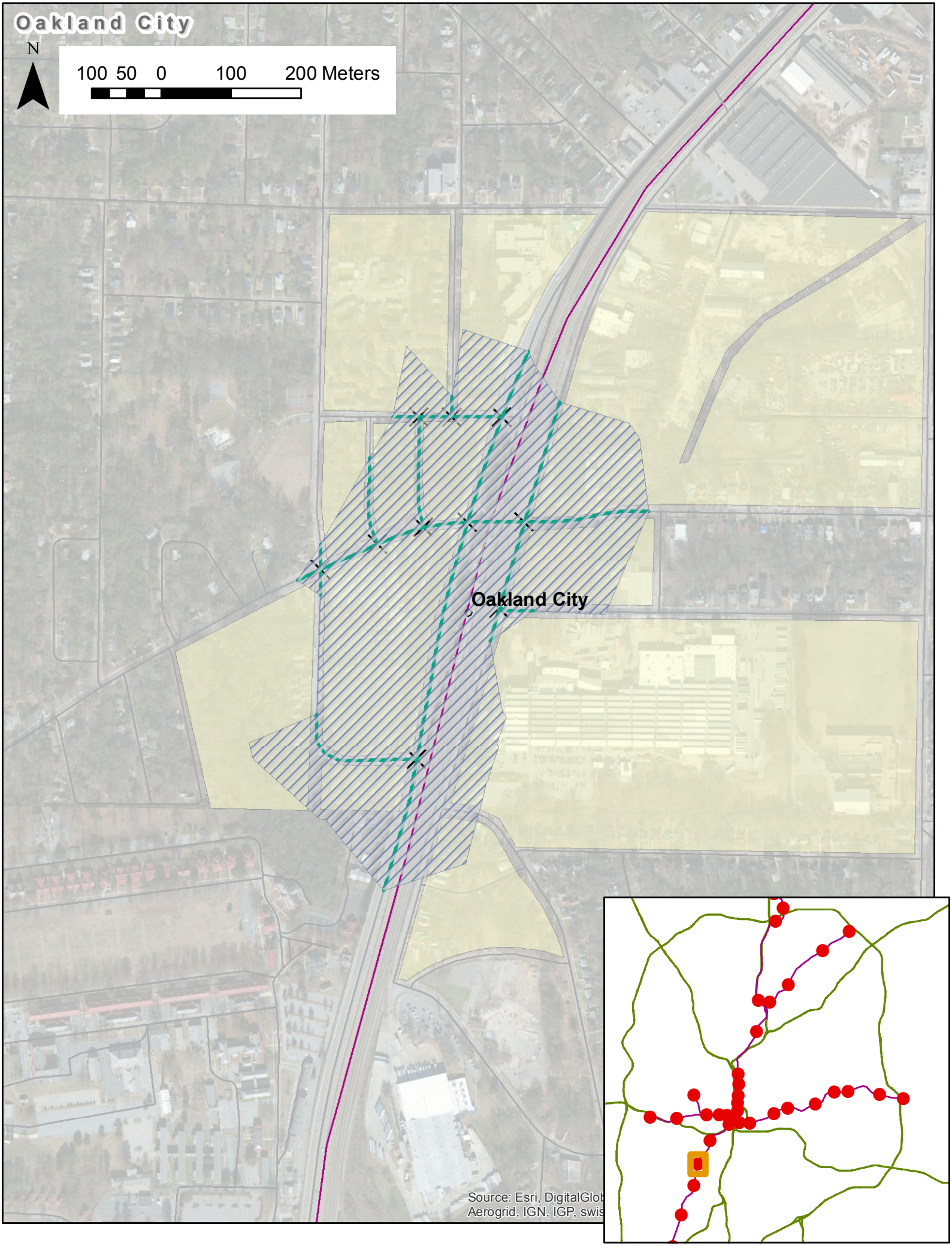
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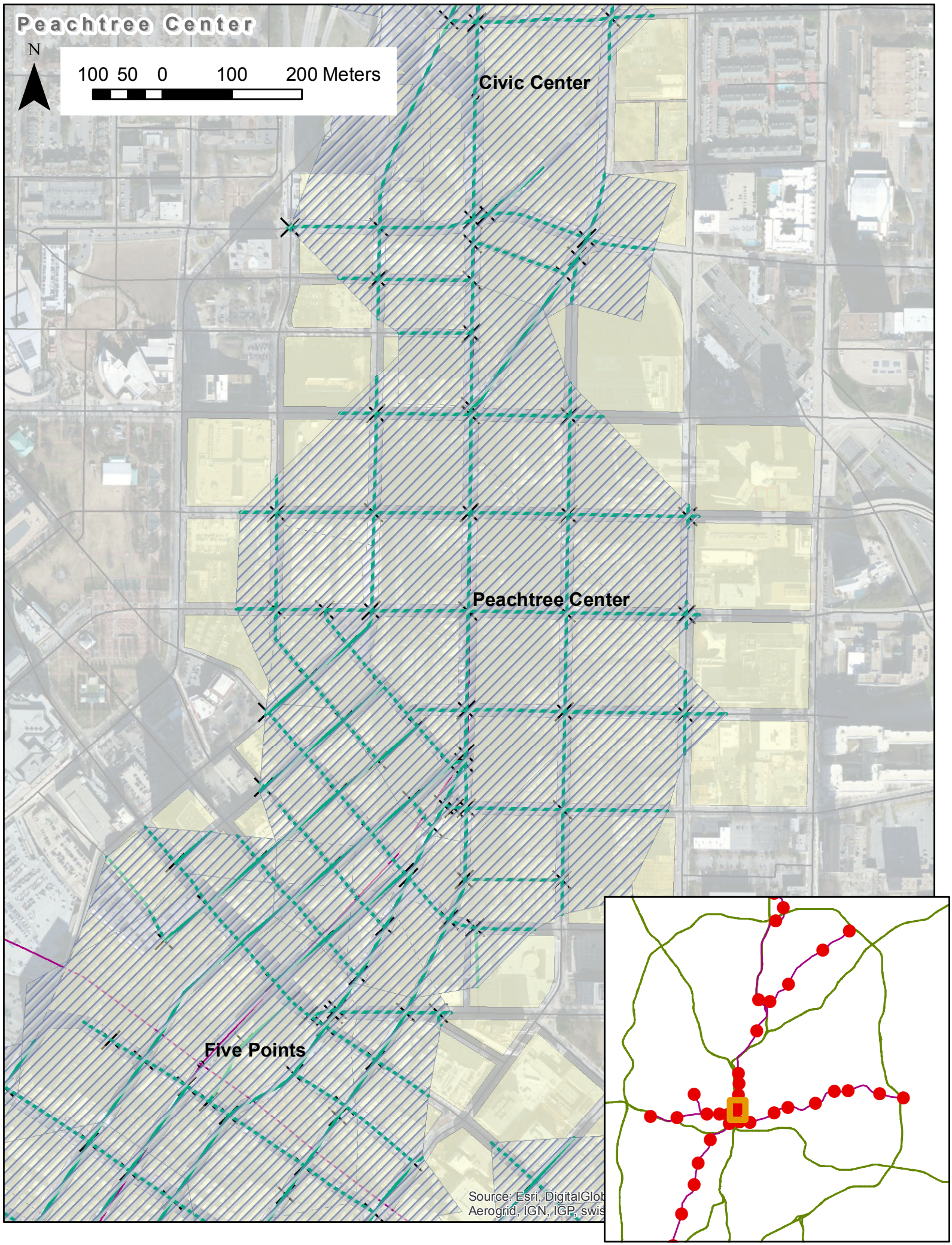
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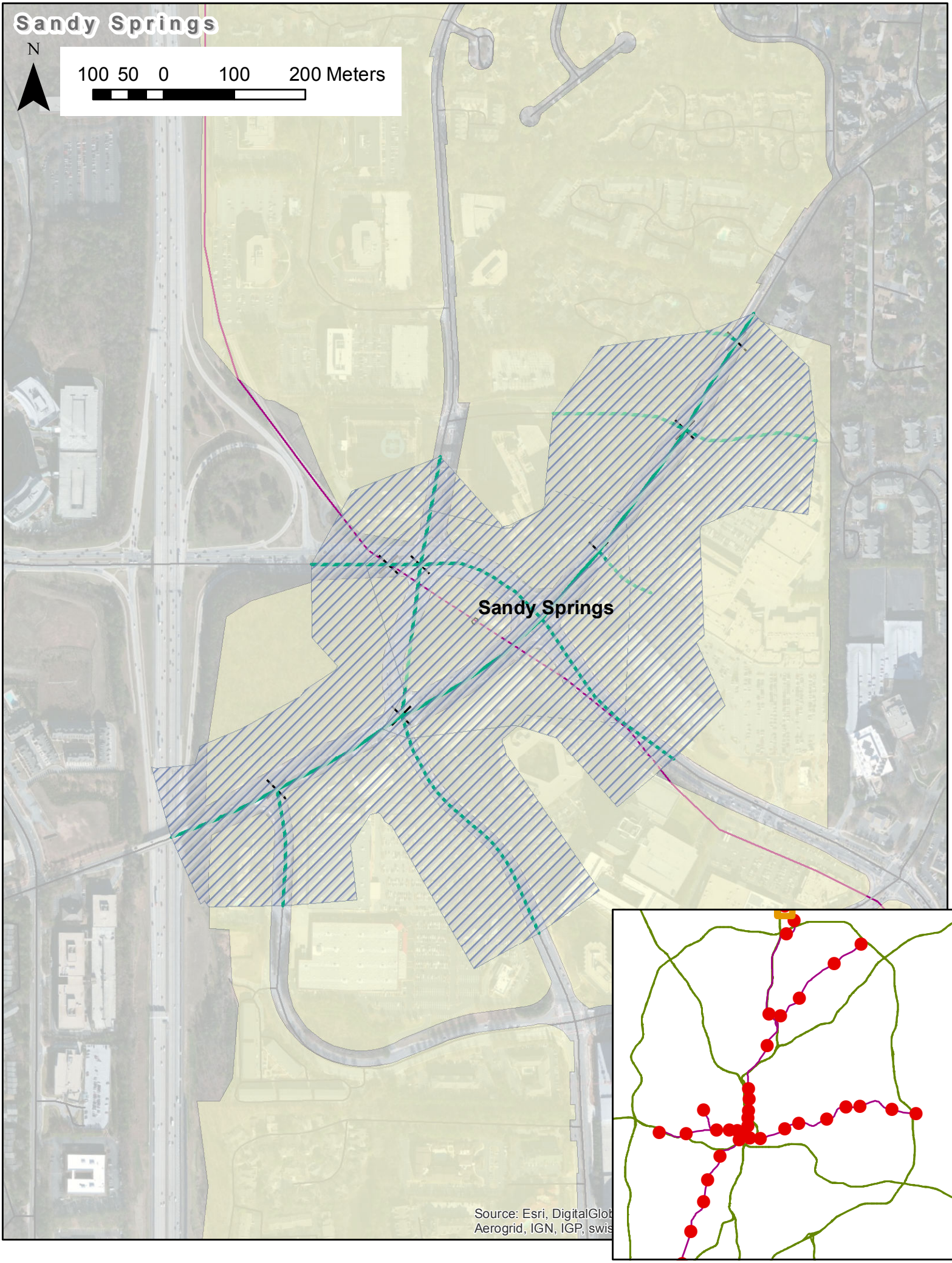
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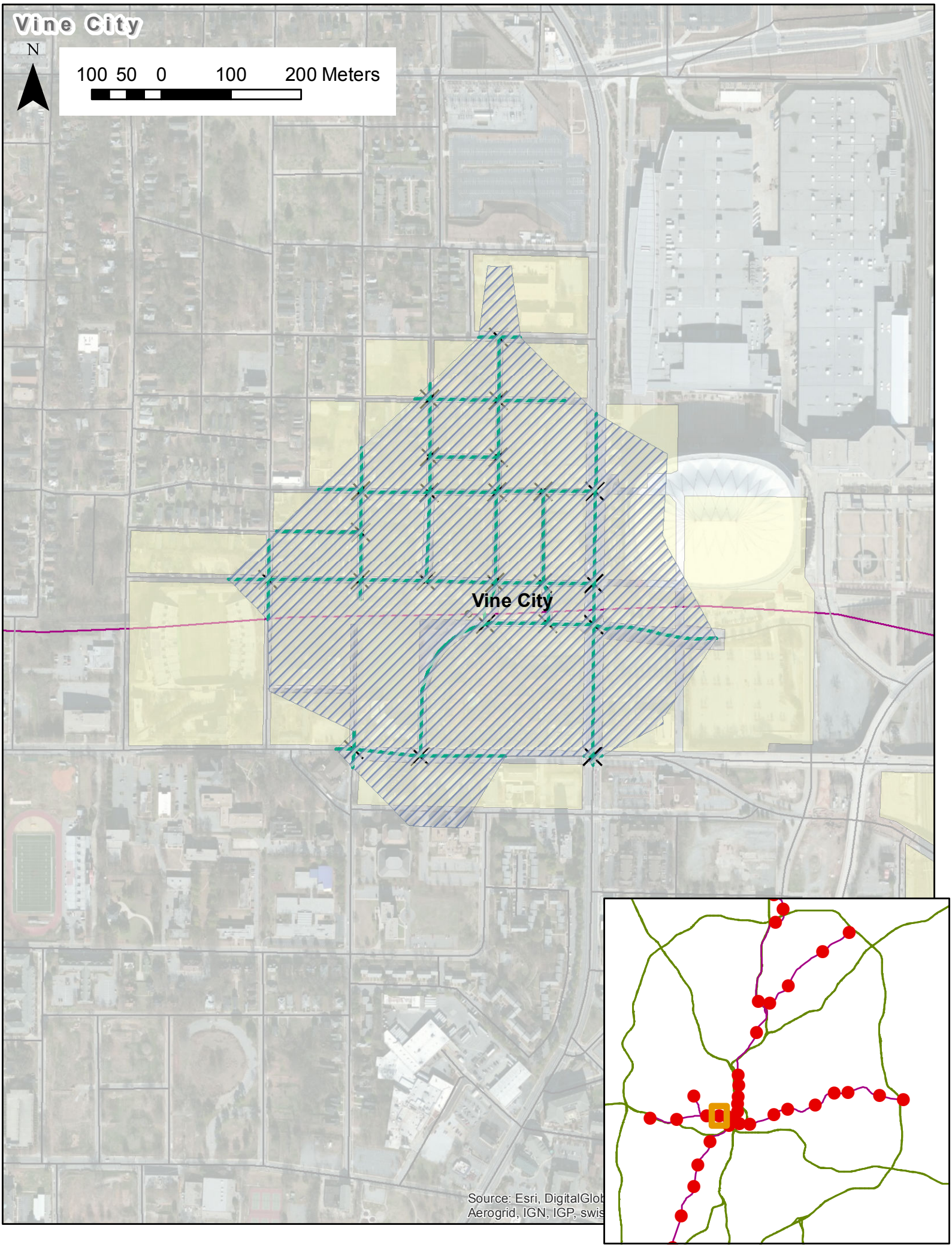
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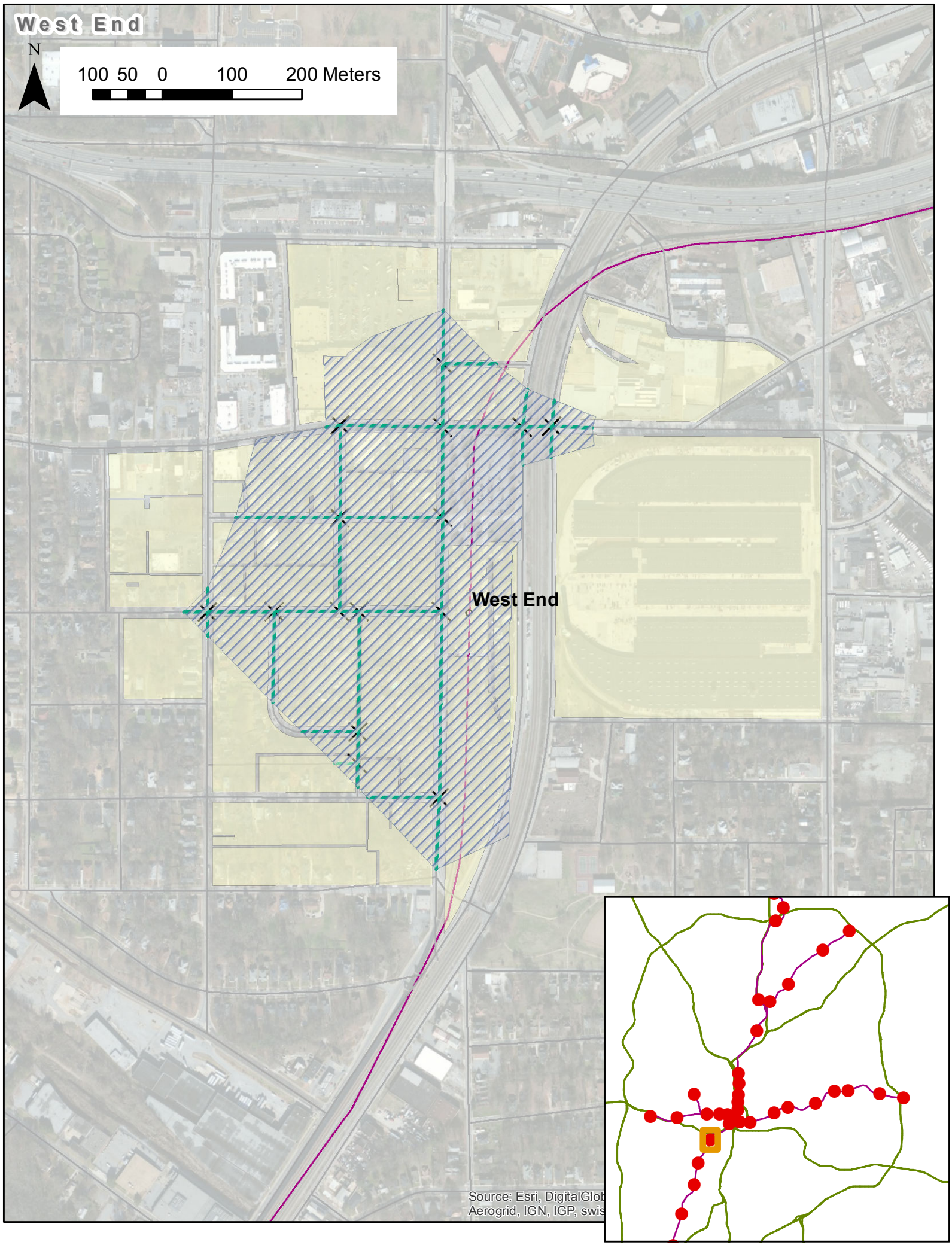
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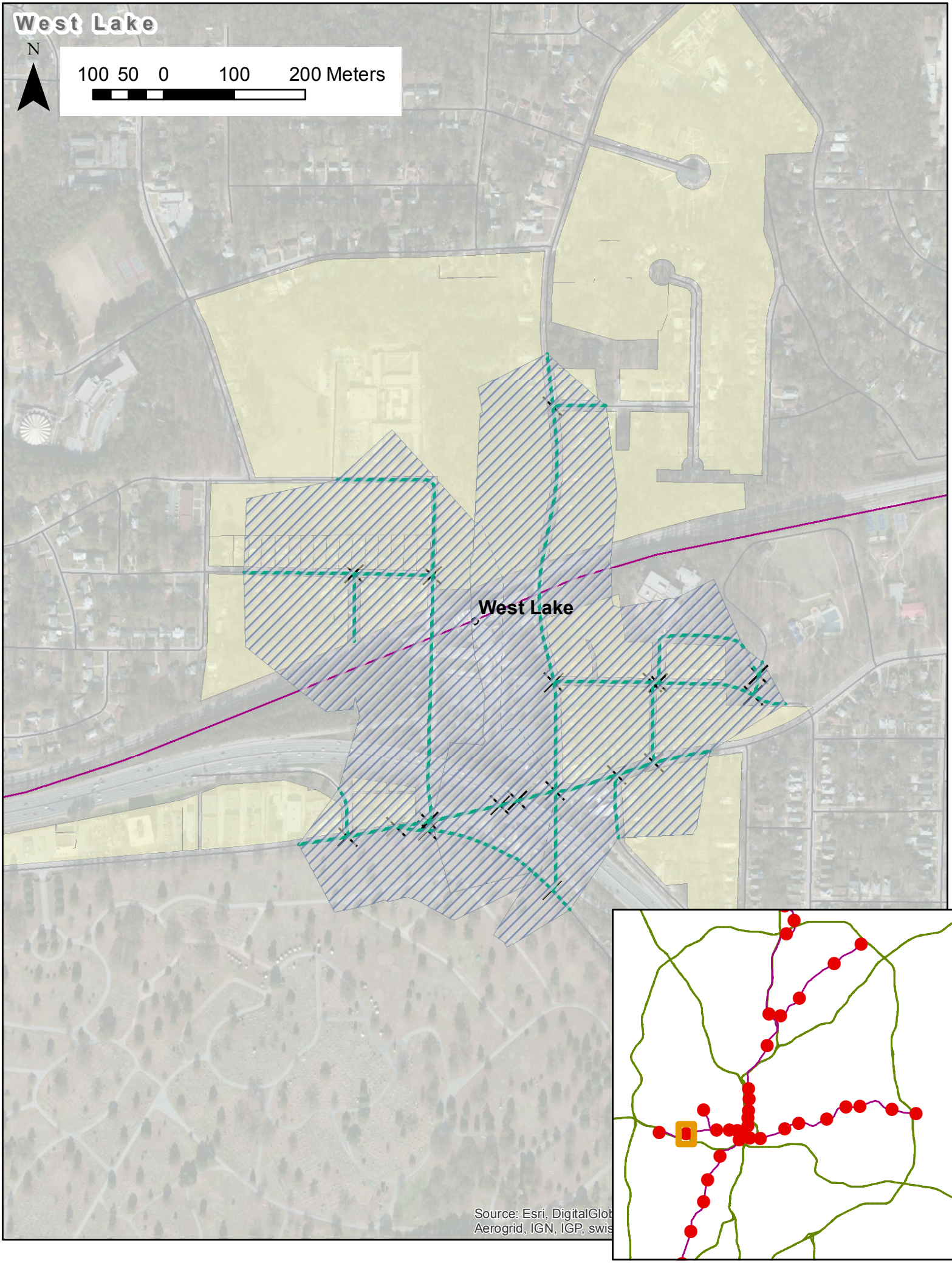
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Source: Esri, DigitalGlob
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Chapter 4

Discussion of Findings and Policy Recommendations

4.1 Discussion of Findings

4.1.1 Right of Way length and Number of Intersections

Right-of-way lengths per station appear to be roughly similar when compared across systems. While DC and Atlanta show more spread, the medians appear to be close to that of Paris (around 4000m). There is roughly similar amounts of right-of-way potentially available for commercial and residential access, implying that this should not affect system-wide viablility of TOD. The plot of number of intersections, however, shows that Atlanta's station areas are generally skewed lower - there is greater probability of station areas with fewer intersections, implying lower connectivity, and lower viability for TOD.

4.1.2 Number and Size of Blocks (log plot)

While the number of blocks within station areas appears to be similarly distributed across each of the systems, Paris blocks are more likely to be smaller with much less variation in the size of blocks than in DC or Atlanta. Atlanta shows the most variability in block size, implying a very heterogeneous urban form - TOD might be supportable at some stations more than others.

4.1.3 Avg Distance to Next Station (m) and Ridership

This plot shows that there is unexpectedly much more variation in walking distance from one station to the other in DC than in Atlanta, while some stations in DC's core are closer together. Ridership for DC's metro appears to be skewed much higher than the data for Atlanta, implying more transit mode share in general for DC than Atlanta. DC's stations also display more variability than MARTA, possibly implying a wider variety and spread of land uses.

4.1.4 Regression Results

The regression results show that the number of intersections near the station appears to have the greatest statistical significance in explaining variation in ridership (entries). For the combined and WMATA-only regression, the relationship is positively related - more intersections imply a greater number of entries. MARTA's regression reversed

this trend, leading to possible questions about what type of intersections are involved or other design variables that influence ridership. Additionally, block size appeared to have only a small, barely negative impact on ridership. Finally, number of blocks appeared to have a relatively large negative effect on ridership, seemingly contrary to previous studies. Though not fully developed in this study, some of these variables may show collinearity bias due to their relationship (more intersections might imply smaller blocks; more right-of-way might also imply smaller blocks).

4.2 Policy Recommendations and Conclusions

In more than 50 studies, no one particular variable has been shown to be isolable in order to reduce VMT, increase transit ridership, or fully incentivize walking. The issues surrounding this domain of transportation, land-use, and transit-oriented development will continue to be studied at greater resolution. In the issue of transit-oriented development, however, an appropriate street network creates a framework for successful future projects. Rather than focus on mandating specific mixes of uses, local governments could instead insist on better, denser subdivision, setting the stage for appropriate levels of development.

From the comparison with other cities, several recommendations could be made regarding subdivision policy, especially when considering new transit-oriented development near fixed-route transit stations. While length of right-of-way and number of blocks appeared to have smaller variation across systems, number of intersections, block size, and distances between stations appeared to vary widely between systems. This supports the anecdotal advice from transit-oriented development advocates such as Peter Calthorpe that small, highly-connected blocks are the most conducive to transit use. This result also appears to fit within the studies analyzed by Ewing and Cervero.

The City of Atlanta and MARTA should therefore work with developers to create more highly-connected developments with many intersections that increase pedestrian choice and navigability near MARTA stations. Incentives to create smaller blocks - more approaching Washington, DC's median value of 21,427.38 square meters (a little over 5 acres) - and developing a more connected network with more intersections (more than 20 within the $\frac{1}{4}$ mile station area), might substantially increase navigability by pedestrians. Though re-subdivision of existing property is difficult and often impossible in many existing conditions, the possible availability of large tracts of land around such stations as Doraville, Lakewood-Fort MacPherson, and Bankhead might offer opportunities to create transit-oriented development that best serves transit users and pedestrians.

Chapter 5

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